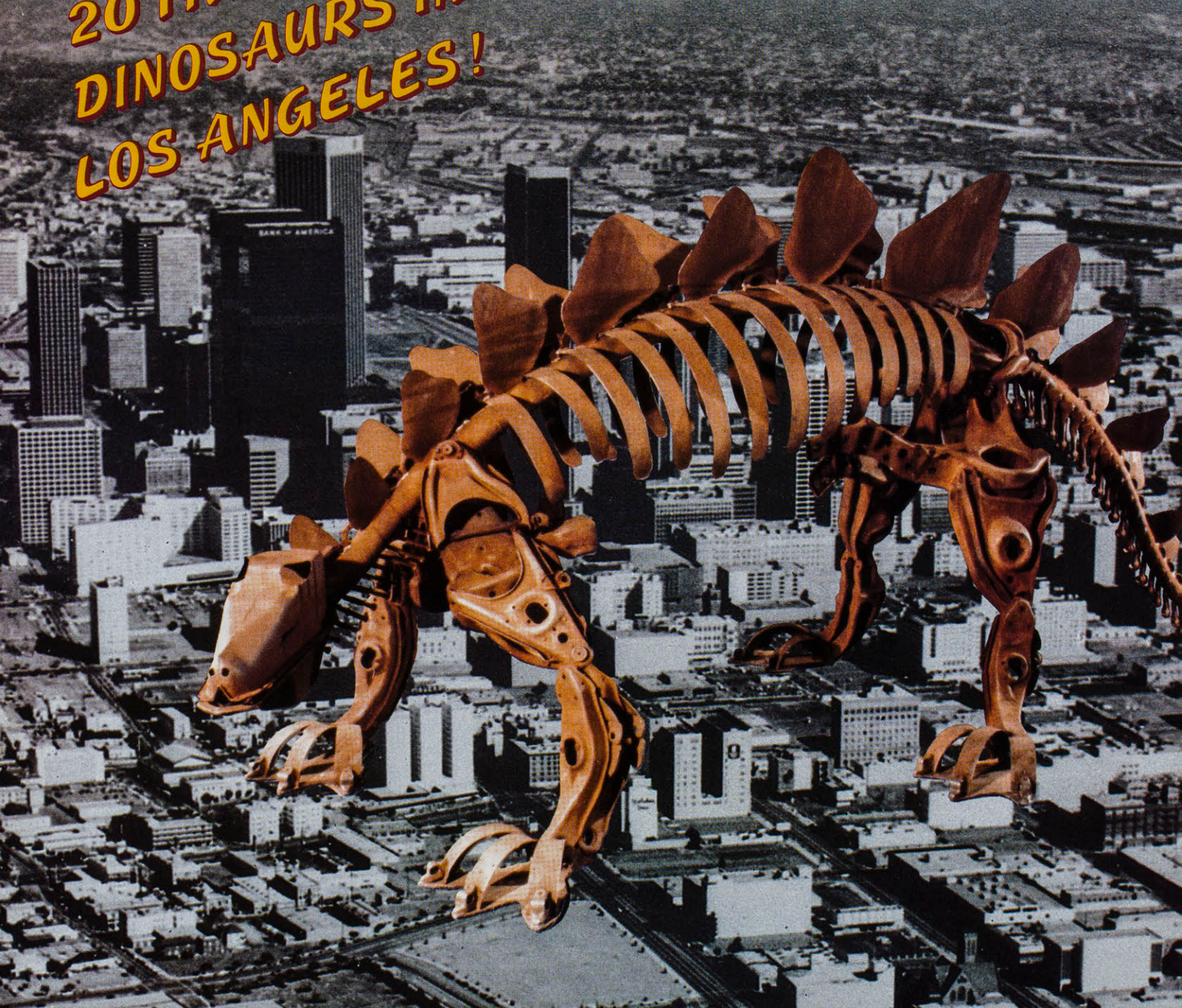


TERRA

THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY

VOL. 21, NO. 3 / WINTER 1983

20TH CENTURY
DINOSAURS INVADE
LOS ANGELES!



MUSEUM ON THE MOVE

DOWN UNDER

Don Chaput of the History Division has returned recently from a six-week research trip to Queensland, Australia. The object of his research is historical mining, milling, and smelting endeavors in Australia's northeastern province, and their relationship to mining practices in California and the West.

Chaput is particularly interested in the similarities between copper and gold extraction and processing as practiced in Queensland from the 1880's to 1910, and those operations in the West. Research centered in libraries, records centers, and at mines in the Brisbane, Townsville, and Cooktown regions has pointed out some of the reasons for this similarity. Many of the people and much of the machinery involved in the Australian operations originated in the U.S.

Many of the engineers and metallurgists educated and trained in the American West were employed in Queensland to develop mineral resources there. These Americans sent for machinery and equipment from home, principally from Denver and San Francisco manufacturers.

Chaput's research on the Western and Australian metals industry already has resulted in publication of several brief monographs, and now he is in the early stages of arranging an exhibit for the museum.

HOGUE-HENDERSON ZAMBIA EXPEDITION

Dr. Kenneth E. Stager, Senior Curator Emeritus at the Museum, and Dr. John W. Wright, Curator of Herpetology, have recently returned from eastern Zambia where they participated in the 1982 Hogue-Henderson Zambia Expedition. The main field camp of the expedition was located northwest of Mfuwe on the banks of the lower Luangwa River.

While Wright was busy assembling a large and varied collection of the reptiles and amphibians of the Luangwa Valley, Stager—with the help of two trained preparators from Kenya—was likewise engaged in making a comprehensive collection of the small mammals of eastern Zambia.

Both curators are enthusiastic over the results of their efforts. Approximately 1,000 specimens of snakes, lizards, frogs, toads and freshwater fishes were secured by Wright, while over 600 specimens of small carnivores (mongooses and civets), rodents, and bats were collected and prepared by Stager and his Kenyan assistants. In the collections are a number of species not previously recorded from

eastern Zambia and a few that have never before been known to occur in the Republic.

The scientists report that the greatest hazard and deterrent to their nocturnal collecting activities and sleep was the presence of hundreds of grazing hippos and large numbers of elephants about the base camp area each night. Extreme care also had to be observed while working along the banks of the big Luangwa River because of the large and hungry population of 15-foot crocodiles. Many elephants were attracted to the camp in their search for large bean-like seed pods that were falling from the trees that shaded the camp area. The thin thatch fences that encircled the camp compound proved no deterrent to the hungry pachyderms, and they moved in and out of the camp like maneuvering Sherman tanks. Both scientists complain that their sleep was erratic, due to the sounds of crashing fence and heavy breathing and noisy gut rumblings of these large beasts, who were far too close for comfort.

This most productive expedition was made possible through the generous funding by the expedition's sponsors—the late Mr. A. Howard Hogue of Santa Barbara and Mr. Simon Henderson, III, of Lufkin, Texas.

ORNITHOLOGISTS ON CHRISTMAS ISLAND

Dr. Ralph W. Schreiber, Curator of Ornithology, spent 10 days in November on Christmas Island, Central Pacific Ocean, with Betty Anne Schreiber, Research Associate in the Museum, and Warren King, Head of the U.S. Section of the International Council for Bird Preservation. Dr. Schreiber has been studying the populations of birds on this island since 1967, concentrating on the boobies, frigate birds, and tropic birds.

Christmas Island is on the equator and is known for the sameness of the climate and almost continuous breeding by some birds throughout the year. It was thus somewhat of a shock for Schreiber to find essentially no birds present during November. The island has experienced unusually heavy rains since August, accompanied by high tides and a complete reversal of the usual wind and current direction. Schreiber postulates that two things may have happened: The adult birds may not have been able to tolerate the hard, almost continuous rains and may have left the area, deserting their young. A second possibility is that drastic changes occurred in the oceanic currents where the birds feed, thus shifting the fish/squid availability. The lack of food thus caused the adults to go in search of food, leaving their young to starve, but saving themselves for other breeding attempts.

The absence of adults and the large number of dead or dying nestlings was most

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A CANADIAN DINOSAUR PARK

by DALE A. RUSSELL

Photographs by the author

A carcass of the horned dinosaur Chasmosaurus in a stream channel in Dinosaur Provincial Park during the dry season. The small scavenger is Dromaeosaurus. Painting by Eleanor M. Kish; reprinted from Dale Russell's book, A Vanished World: The Dinosaurs of Western Canada (National Museum of Natural Sciences, Ottawa, 1977).



When we were young the world was a strange and fascinating place. It was filled with unexpected surprises, most pleasant and some not so pleasant, and it was very old. We had to become personally independent within a very short span of time relative to the seemingly boundless antiquity of our surroundings. We learned the names of giant objects, like chairs, tables and mountains, and of giant creatures such as Fido, Mom and Dad. We found pictures of creatures like them in coloring books, along with those of strange animals called "lion" (an enormous frightening cat with long hair on its neck), "elephant" (a giant cow with a long nose and misplaced horns), and giraffe (a huge spotted sheep with a snake's neck). We learned about other animals too, such as "struthiomimus" (a bird lizard), and "parasaurolophus" (a two-legged cow lizard with a long crest on its head), but we never saw them in zoos. Our parents told us that it was because these animals, called dinosaurs, lived long ago, before there were men on Earth.

There were lingering questions—where did their skeletons come from?—what was the world like then? The answers in children's books were often simple, and had the effect of turning away our interest in dinosaurs. We may have discovered that *Struthiomimus* and

Parasaurolophus lived together 75 million years ago. It was not easy to find out that magnificently complete skeletons of these dinosaurs had been collected from a unique area of badlands, located in the prairies of southern Canada. The badlands were incorporated as Dinosaur Provincial Park (Alberta) in 1955, and dedicated as a UNESCO World Heritage Site in 1980, because they have yielded an unequaled number and variety of dinosaur skeletons, many of which are displayed in museums throughout North America, as well as in South America and Europe. This wealth of fossil material has played a major role in the development of theories about dinosaurian evolution, physiology and extinction. It is probably the clearest "window" available to mankind through which we can visualize the world of the dinosaurs. Within the four dimensional coordinates of space and time, we know that the dinosaur world is really our world as well. What, then, does this Park contain that may be strange or fascinating to us?

In walking among the exposures of ancient sediments in the Park, it is possible to find the bleached bones of buffalo, deer and jackrabbits. But the remains of modern animals are vastly outnumbered by the petrified bones of animals that inhabited the streams and

floodplains across which the ancient sediments were spread some 75 million years ago. Pieces of dinosaur skeletons are now being uncovered by rain or melt-water from snows across the 80 square kilometers of sculptured sediments at a rate of one to two specimens per year, so that the richness of the Park is continuously renewed. Like the legendary Phoenix, the fossil field is restored in the process of its destruction.

When the Park was established, 250 skeletal fragments of large dinosaurs had already been excavated, together with about 50 specimens belonging to smaller dinosaurs and nearly 100 specimens of turtles, crocodilians and crocodile-like reptiles. The total number of skeletal fragments collected by 1955 was more than twice that taken from any other area of comparable size on Earth where sediments of the Age of Reptiles are exposed. In all, 31 different kinds of dinosaurs have been identified from the Park, at least twice the number found in any of the other major dinosaur-producing localities. A sample of dinosaur remains of this size can reveal subtle clues about the structure of ancient dinosaurian communities and the interactions between dinosaurs and their environment.

The fauna was dominated by eight species of large dinosaurs, each weighing about 2 metric tons and together making



The badlands of Dinosaur Provincial Park. The light sandstones were deposited along the edges of water courses, the grey clays in oxbow lakes, and the brown lignites in marshes and swamps.

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up 85 percent of all the specimens of large dinosaurs collected. These include a tyrannosaur (*Albertosaurus*), an armored dinosaur (*Euoplocephalus*), two horned dinosaurs (*Centrosaurus* and *Chasmosaurus*), and four duckbilled dinosaurs (*Corythosaurus*, *Lambeosaurus*, *Kritosaurus*, and *Prosaurolophus*). According to counts of individual specimens, nearly two-thirds of the large animals normally walked on their hind limbs, whereas most modern mammals are quadrupeds. The fauna owes its unusual diversity to the sporadic occurrence of a dozen other varieties of large dinosaurs, each making up about one percent of the total number of specimens collected. Had the number of skeletal fragments recovered been half as large, the presence of several of these forms in the fauna would not have been detected. Among the rarer forms are such interesting animals as the familiar *Parasaurolophus* and *Styracosaurus*, as well as peculiar armored dinosaurs lacking tail clubs (*Panoplosaurus*) and a species of *Lambeosaurus* with an enormous crest on its head. The number of specimens that has been collected is so large that one major group of dinosaurs is conspicuous by its absence. No scrap of bone belonging to the ponderous brontosaurs has ever been identified in the Park. It is reasonable to conclude that these archetypal dinosaurs were absent from the region, although they are known to have inhabited the southern part of the United States during this time, as well as inland areas of Argentina and central Asia. Perhaps they preferred more arid environments.

The smaller dinosaurs, weighing about 100 kg on the average, are as interesting as the large forms. However, as in game reserves today, skeletons of the smaller animals are rare, incomplete and scattered. Apparently their carcasses were often entirely consumed by predators, or destroyed by trampling and decay processes. If opportunities for the burial and preservation of skeletons of differing

sizes in ancient Alberta were similar to those in modern East Africa, then smaller dinosaurs can be estimated to have been about twice as abundant as their larger relatives. Remains of ten species of small dinosaurs have been identified in the Park to date, and more will probably be discovered. It is known for example, that three major kinds of small, plant-eating dinosaurs lived in western North America at about this time, but they have not been recorded in the Park. Perhaps they too were excluded from the Park for ecological reasons.

The most abundant small dinosaurs were herbivorous dome-headed pachycephalosaurs and fleet ostrich dinosaurs (which probably fed on small animals and eggs). There were also vicious small carnivores with eagle-like claws on both fore and hind limbs, peculiar stork-legged dinosaurs and alert small bipeds (*Stenonychosaurus*) with large eyes which may have hunted rodent-like primitive mammals. *Stenonychosaurus* are particularly interesting because of their enlarged brains, visual fields that overlapped in front of the head and an opposable finger in the hand. They had reached a mammalian level of brain evolution, a condition attained by at least two other species of small dinosaurs in this fauna (*Dromiceiomimus*, *Saurornitholestes*).

The dinosaurs that inhabited the region of Dinosaur Provincial Park some 75 million years ago are thus typical of an advanced phase of dinosaurian evolution. There were nearly twice as many species of dinosaurs in the Park as have been identified in well-studied dinosaur faunas which were in existence 140 million years ago. Their backbones are more clearly separated into specialized neck, hip and tail segments than are those of primitive dinosaurs and crocodiles. Many had relatively long and graceful legs, as can be verified at a glance by comparing the slender hind limb of an *Albertosaurus* skeleton with the stubbier structure in 140 million year old

Allosaurus. Although not as well documented as in the ancestry of the modern horse, the evolution of running adaptations in ostrich dinosaurs is comparable in duration and in attainment of structural perfection. No living reptile possesses a brain that even approaches in relative size the brain in some of the small Park dinosaurs.

Curiously, it is not widely appreciated that dinosaurs as a group had very large eyes, irrespective of the size of the animal. The diameter of the eyeball can be determined from small bony ossicles that were imbedded in the "white" of the dinosaurian eye. The eyeball is thus known to have been physically smaller in some giant brontosaurs than it was in the small, graceful ostrich dinosaurs. However, the average dinosaurian eye was larger than the largest eye known in any living land animal. The human eye is about the size of the smallest dinosaurian eye known, which occurs in small plant-eating forms that apparently inhabited semiarid steppes. Dinosaurs were not an evolutionarily static group, and those whose remains are preserved in the Park were relatively sophisticated creatures that lived near the end of the Age of Reptiles.

Seventy-five million years ago a low coastal plain occupied southern Alberta. The climate was warm and wet. Seasonal floods carried sediments from the Rockies in the west, across a buried ridge located within the boundaries of the present Park, and ultimately into a shallow mid-continental sea that covered most of what is now Saskatchewan. The buried ridge (Sweetgrass Arch) is a very ancient geological structure that was slowly uplifted many different times in Earth history. A slight elevation was apparently occurring as the sediments now exposed in the Park were being deposited, and a small increase in the elevation of the land surface was produced immediately above the ridge. This in turn caused important changes in plant and animal commu-

nities living nearby, just as on modern flat floodplains. When Pierre Béland, of the Department of Fisheries and Oceans [Canada], and I studied the paleoecology of the Park in 1978, we discovered to our surprise that sedimentary patterns and dinosaur distributions were apparently affected by the subsurface ridge.

Twelve kilometers west of the ridge crest the sediments contain large quantities of clay, indicating slowly moving water. Here, skeletal fragments of small dinosaurs and aquatic vertebrates outnumber those of large dinosaurs, and less than half of the latter belong to duck-billed dinosaurs. Small, isolated bones of salamanders, lizards and mammals are relatively abundant. In the vicinity of the ridge itself, the sediments are dominated by sandstones, and even cobblestones occur locally, indicating rapidly flowing water. Here skeletal fragments of large dinosaurs outnumber those of smaller animals by a ratio of more than three to one, and isolated remains of tiny vertebrates are rare. Two-thirds of the large

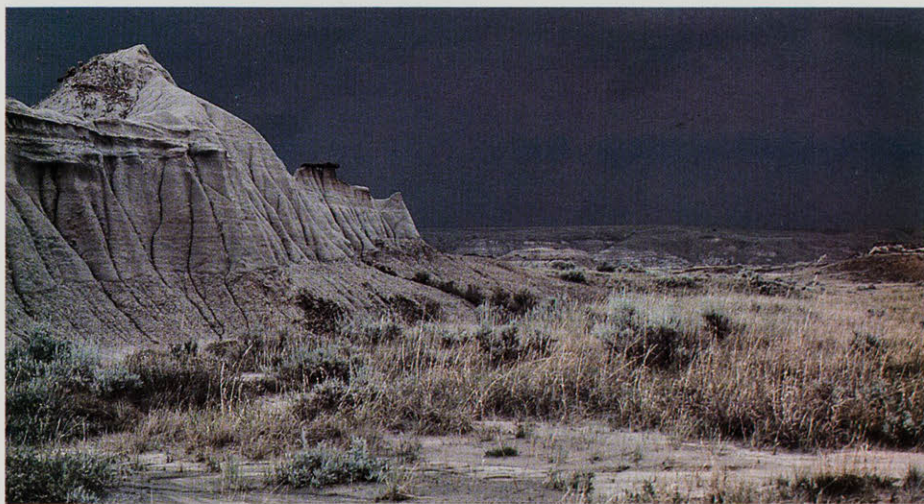
dinosaurs are duckbilled dinosaurs. We interpreted the sedimentary and fossil evidence as implying the existence of swampy, densely vegetated environments to the west, and better drained, more open environments to the east.

The relative abundances of plant-eating and flesh-eating dinosaurs in the Park were used by Robert Bakker of Johns Hopkins University and James Farlow at Indiana University-Purdue University at Fort Wayne as a means of estimating dinosaurian metabolism. The food requirements of predators are determined by their metabolic rates, and the number of predators is limited by the availability of their plant-eating prey. Cold-blooded predators (such as crocodiles) require less food than warm-blooded predators (such as wolves), and—other factors being equal—a greater number of the former can live in equilibrium with a given population of herbivores. In African reserves one percent of the weight of the total population of large mammals is composed of carnivores; the equivalent

figure is six percent for the dinosaurian assemblage from the Park. We must conclude that either the dinosaurian carnivores were cold-blooded, or that the Park assemblage was biased in some unknown manner in favor of the preservation of predator skeletons. Similarly, if dinosaurian herbivores were cold-blooded, a given population of growing plants could support more animals than if they were warm-blooded. The relatively small size of the brain in the large carnivorous and herbivorous dinosaurs, and in living cold-blooded vertebrates, suggests that large dinosaurs were generally cold-blooded. Larry Tieszen, of Augustana College (South Dakota), and I hope to clarify the question of dinosaurian metabolism by studying the ratios of stable isotopes of carbon in minute amounts of collagen still remaining in dinosaur bone from the Park. High metabolic rates discriminate against the heavier carbon isotope in the synthesis of proteins.

Should the larger dinosaurs be shown to have been cold-blooded, the implications are no less spectacular than if they were warm-blooded in terms of an exotic appearance for the Park fauna. The soils of the ancient floodplain show abundant evidence of enrichment from ashfalls blown from volcanoes to the southwest. Plant fossils provide evidence that rainfall was probably heavy, particularly during the summers. The abundance of detritus from trees of the bald cypress-redwood family evokes images of damp, low-lying fog. Winters were probably frost-free, but rings in petrified wood and reptile bones show that growth slowed during this season. Environmental conditions such as these usually promote relatively lush plant growth, which in turn can sustain dense populations of vertebrate animals. We may presume that dinosaurs were relatively more numerous here than in other, less favored regions of the continent. Indeed, the volume of skeletal tissues of plants and animals that were mixed into sediments now exposed in the Park bears witness to high biologic productivity.

Dinosaurian population densities can be estimated by analogy with mammalian populations living under climatic conditions which are equally favorable to plant growth, after making corrections for differing metabolic rates assuming that large dinosaurs were cold-blooded. Thus populations of giant herbivorous turtles on the Aldabran Atoll in the Arabian Sea are about ten times more dense, by weight, than are those of large mammalian herbivores in a similar climatic regime on the African mainland. The abundance of inorganic nutrients and water in the ancient environments of Dinosaur Provincial Park imply total population weights for cold-blooded dinosaurs that were roughly ten times heavier than those of large mammals in the most lush of African big game re-



The badlands of Dinosaur Provincial Park present marvelous natural forms, particularly when viewed against the background of approaching prairie storms. On overcast days, with no sun to orient by, it is easy to become lost in these badlands.





When dinosaurs lived in Dinosaur Provincial Park, the vegetation was quite different, being more tropical in nature. Instead of open prairie, bald cypress swamps like those of the Okefenokee Swamp in Georgia (left) and forests of podocarps similar to the swamp podocarps of New Caledonia (center) were common.



A fossil conifer log (probably belonging to the bald cypress family) 43 cm (18 inches) in diameter and 3.6 m (12 ft) long is seen eroding from the sediments of the Dinosaur Provincial Park.



Above: Scenes similar to these prop-roots of a screw-pine stand in western Java, Indonesia, may have been common in Dinosaur Provincial Park.



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Right: Large trails formed by the dense populations of dinosaurs may have criss-crossed these river sands of Dinosaur Provincial Park.

Below and right: The dinosaur trails may have looked similar to these modern big game trails in Zambia. It is not difficult to imagine similar trails made by large dinosaurs, which are known from trackway evidence to have walked in single file.



Left: The black carbonaceous streaks seen in these rocks of Dinosaur Provincial Park probably represent dinosaur dung reworked into quiet-water sediments.

serves. The numbers translate, according to the relative abundance of the skeletons of different kinds of dinosaurs in the Park, into population densities for duck-billed dinosaurs of 51 animals per square kilometer, for horned dinosaurs of 28 animals, for armored dinosaurs of 15 animals and for tyrannosaurs of 9 animals. The figures yield an enormous overall density of one two-ton animal per hectare.

The groups of dinosaurs in the ancient Park may thus have been truly spectacular by comparison with the richest concentrations of living big game animals. Their lower food requirements and activity levels would nevertheless have been compensated by their greater numbers to produce comparable disturbances in their surroundings. In contrast to the pristine scenes depicted in most reconstructions, the Park would have appeared "lived-in," resembling a barnyard more than a forest reserve. There would be broken branches, barked trees and shredded fronds, and the effects of browsing on vegetation would be visible everywhere. Stream channels would be blocked and trampled into U-shaped channels, like small glacial valleys, by the repeated passage of groups of animals, and game trails would in turn define the courses of expanding waterways. Clays on the floodplains would be thoroughly plowed by the feet of large herbivores during the wet season, and the quantity of sediment suspended in rivers would be enhanced by animals bathing to regulate their body temperatures or possibly to rid themselves of parasites. The fibrous dung of plant eaters would be ubiquitous, falling to the ground at a rate of 500 metric tons per square kilometer per year and producing the abundance of carbon streaks seen in Park sediments. A tyrannosaur would never have been far from its prey, and a disproportionate number of herbivores were forced to rely on armor and horns instead of flight for protection. The setting suggests half-destroyed, half-regenerating landscapes inhabited by large creatures whose movements were generally slow and oddly deliberate. Their world was one of languor, infrequently punctuated by moments of high terror and brutality.

Some details may now be emerging from the fossil record on other possible interactions between Park dinosaurs and their environments. For example, tyrannosaur teeth are large but intermesh poorly, so that they would not have been able to clean the carcass of a large prey animal as well as do modern lions and jackals. Many small carnivorous dinosaurs were evidently the scavengers of their day, together with some large, vulture-like flying reptiles, but none developed the bone-crushing dentitions of hyenas. A mode of tyrannosaur hunting is suggested by the gray, sinuous trunks of toppled trees on the African savanna. The eyes in tyrannosaurs were carried high

in the skull, and a solid, foot-like pelvic structure could support the animal's weight, leaving its legs comfortably flexed with both feet resting normally on the ground. Large mammals today that are standing quietly in dark shadows in the brilliant heat of a tropical day are surprisingly difficult to see. Imagine walking up to what appeared to be a waist-high windfall of tree trunks in the ancient Park, and noticing that "knots" on a "fallen log" were actually warty eye sockets. What would your feelings be as an innocuous gray tree trunk rose to transform itself into a tyrannosaur?

The feeding habits of dinosaur herbivores also differed from those of living mammals. Most plant-eating dinosaurs possessed shearing dentitions and a body structure suited for browsing on woody vegetation up to three to four meters above the ground. Different species apparently cropped different levels of vegetation, but duckbilled, horned and some armored dinosaurs, which make up nearly 90 percent of the aggregate body weights of plant-eating dinosaurs in the Park, were browsing animals. Only *Eo-plocephalus*, the armored dinosaur with a tail club (the original Canadian Club!), was restricted to grazing on low herbs growing on the ground. Today grazers usually far outnumber browsers in most big game faunas. Plantscapes of the dinosaurian age were probably dominated by bushes and trees, and there were no fertile grasslands such as those now typical of large areas of the globe. A grass-like growth form was mimicked by other plants, including ferns, that did not form so dense a ground cover.

Intricate mosaics of undulating strata of sandstone and clay are characteristic of sediments in the Park badlands. They show that the ancient soils probably also differed from place to place. Skeletal fragments of various kinds of dinosaurs tend not to occur in species groups, and there is no indication that particular associations of dinosaur species were grouped together in particular habitats. No similarly varied fauna of living aquatic or amphibious big game animals is limited to river or stream-margin habitats. The fossil evidence thus suggests that loose associations of dinosaurs moved through relatively small, but environmentally discrete patches, browsing on small clumps of suitable vegetation as they passed.

From time to time the numbers of certain species of plant-eating dinosaurs may have grown beyond the capacity of their preferred plant species to provide them with food. Lying in the sediments of the Park in mute witness to local disasters are scattered bone beds apparently composed of the jumbled bones of only one species of horned or duckbilled dinosaur. The biological implications of mass-death associations are being studied by Philip Currie of the Tyrell Museum of Alberta. At one site bones of an esti-

mated 350 individuals of the horned dinosaur *Centrosaurus* were found covering 2,000 square meters along an ancient riverbank. The bones can be grouped into three size classes, suggesting that, if the animals bred seasonally, three years were required for them to reach maturity. The fossils also show that one animal in seven was not fully grown and, by implication, that growth and death rates of *Centrosaurus* were similar to those of modern big game herbivores. It is difficult to avoid the conclusion that the creatures were clustered together in a herd prior to their demise, and soon thereafter represented more than 600 metric tons of decaying flesh concentrated in a very small area. Within a few days of subtropical temperatures, the ensuing aroma must have been overwhelming. Scavenging carnivorous dinosaurs were attracted to the site and many left behind their teeth, broken off on horned dinosaur bones. A few more bones were also found in the association, possibly added as a result of combat between predators.

There were sounds as well as smells. Peter Dodson, of the University of Pennsylvania, and his student David Weishampel have studied the hollow bony crests on top of the skulls of some duckbilled dinosaurs from the Park. These crests were used as resonating chambers in the production of calls. Ornaments on the crests can be used to separate animals according to sexes, but within each species the acoustical properties of male and female crests remained approximately the same. *Corythosaurus*, *Lambeosaurus* and *Parasaurolophus* individuals could thus be identified according to the sound of their trumpeting. In immature duckbills the crests were not well-developed, and their calls were about as highly pitched as the human voice. The ears of adults were, however, sensitive to them, suggesting a degree of parental concern. An adult *Parasaurolophus* bellowed in the range of the deepest notes of an organ, probably producing a rather macabre effect. Fully one-third of the large dinosaurs in the Park were crested hadrosaurs, and the sound levels they could sustain must have been impressive in comparison to the more modest choruses of modern frogs.

Much of the plant material preserved in the Park is so badly disintegrated that identifying features are difficult to discern. Exceptions include petrified conifer trunks nearly 16 meters long and more than one-half meter in diameter. Some fossil wood has not been permineralized, but its cellular structure remains intact and it is even capable of sustaining flame. Impressions of rush-like leaf fragments are common, although only a few leaves belonging to broad-leaved trees have been collected.

Through an analysis of fossil pollen and spores preserved in Park sediments, David Jarzen, of the National Museum of Natural Sciences (Canada), has been able to document the existence of at least 85 different kinds of plants. Ferns and flowering plants dominate the microfloral assemblages, and—among the latter—parasitic plants distantly related to mistletoe are particularly abundant. The plant record contains no evidence of the ecological trend shown by the changing abundances of fossil skeletons as the buried ridge in the center of the Park is approached. Currents of air and water must have mixed the ancient pollen and spores to the point of completely obscuring the trend. The presence of such exotic forms as tree ferns, cycads, podocarps, phylloclads and proteas must have lent a southern hemisphere flavor to the floral milieu.

The austral ambience would to some degree have been reinforced by the animals. Monitor lizards were present, as were small squirrel-like mammals that were distantly related to the duckbilled platypus and may also have laid eggs. Marsupials or pouched mammals were abundant and diversified, some nearly attaining the size of the modern opossum. The ostrich dinosaurs resembled large ground birds, such as the emu and rhea, in their body form and probably to a certain extent in their habits. But where are the

modern southern analogues of giant flying reptiles with wingspans equaling 13 meters that left their remains in the Park? It is true that none of the larger dinosaurs found here weighed as much as a large bull elephant, so that impressions of gigantism would not have been overwhelming. Yet there is no living animal whose body form authentically recalls the dinosaurian compromise between the structure of birds, reptiles and mammals. Where are the bipedal big game faunas of our world?

The petrified residues of Dinosaur Provincial Park indicate that its environments were unique in terms of our experience. A visiting biologist would have felt the strangeness, a slower pulse of life, and perhaps would even have been reminded of modern oceanic islands by certain primitive plants and dense reptile populations. The biologist, accustomed to modern animal behavior patterns, would have been struck by the behavioral crudity of all animals, for central nervous systems of many creatures, including mammals, were simpler then. Nevertheless, that world gave us the seeds of our own, winnowed by an awesome extinction and the vicissitudes of a vast expanse of geologic time.

The fossil debris exposed on the badlands of the Dinosaur Provincial Park can be interpreted in a broader perspective.

The dinosaurian assemblage preserved there is conventionally accepted by specialists as having been unaffected by the stresses that brought about the extinction of the dinosaurs 10 million years later. It has therefore provided a yardstick against which later dinosaurian assemblages are measured to determine the presence or absence of a gradual decline. In my view, the great abundance of skeletal material in the Park has led to the recovery and identification of an unusually large number of different kinds of dinosaurs. A smaller variety of dinosaurs has been identified from localities where younger strata are exposed because the numbers of skeletons excavated from them are smaller. Unfortunately, the smaller numbers of specimens in the later dinosaurian assemblages has often been overlooked, giving rise to a widely accepted theory that dinosaurs gradually dwindled in number and variety toward their ultimate extinction.

Many of the rarer species from the Park would not have been identified if the total number collected were reduced to one-third, equaling the number collected from other badlands where skeletons of the last dinosaurs have been collected. In addition, the ecological richness of the ancient Park probably attracted a greater variety of dinosaurs than would have been the case if a more uniform set of environmental conditions were present.

Dense populations of large animals can have a severe impact on the environment, as seen in these floodplain deposits deeply plowed by big game trampling during the wet season, Luangwa Reserve, Zambia.



Note the browse line beneath the crowns of the trees a few meters above the surface of the ground.

These broken trees near Lake Manyara, Tanzania, show the effects of elephant browsing. A similar "lived-in" look may have been seen in Dinosaur Provincial Park.



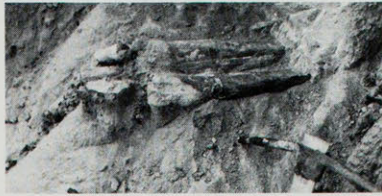
Vultures feeding on a rhino carcass, with baboons and elephants in the background, Lake Manyara, Tanzania. Dinosaur game populations may typically have been much more dense.

Dinosaur bones were probably scattered after death by scavengers in a manner similar to the scattering of these elephant bones in the Luangwa Reserve, Zambia.





Dinosaur fossils eroding from the rocks are common in Dinosaur Provincial Park. Here, a tibia of a large carnivorous dinosaur (tyrannosaurid) is exposed.



An arm of a duckbilled dinosaur is seen extending from an exposure of river sands, Dinosaur Provincial Park. A complete, articulated skeleton, buried in the bank, is suggested by this occurrence.



A neck shield and nose horn of the horned dinosaur *Centrosaurus*, probably from different individuals in a mass-death occurrence, appear eroding from the rocks, Dinosaur Provincial Park. The specimens are now in the collections of the Tyrrell Museum, Alberta.

Finally, elsewhere in western North America the badlands where remains of the last surviving dinosaurian faunas are preserved have often produced as many specimens per unit area as have the badlands of Dinosaur Provincial Park. I have found no good evidence that dinosaurs were actually declining as the end of the Age of Reptiles approached, nor that the dinosaurian assemblage of the Park was in general terms unlike those in younger sediments. There were, of course, differences in the kinds of dinosaurs present, and in the larger size of the later forms, due perhaps in part to slowly warming climatic conditions.

Therefore the hypothesis that the giant reptiles vanished abruptly does not seem unreasonable to me, although this view is not shared by many other students of dinosaurs. Further, the much-discussed geochemical evidence of extraterrestrial material found around the world in association with the extinctions at the end of the Age of Reptiles seems to pose interesting questions on the kind of stresses that brought about the demise of the dinosaurs. According to one very coherent interpretation, the extraterrestrial material may have resulted from the impact of an asteroid. We live only about 100 kilometers from space—the equivalent of an automobile drive of less than one hour's duration, an astronomically insignificant distance. This proximity should provide a stimulus to consider the possibility of extraterrestrial influences in geologic history. A comparison of the rich animal life of Dinosaur Provincial Park with a world dominated by rodent-like mammals and small turtles a few millions of years later could be a measure of their importance.

Several small dinosaurs in the Park had relatively large brains and were in all probability cleverer than any living reptiles. They represent a discrete evolutionary pathway toward the development of more complex central nervous sys-

tems. The great extinctions had the effect of preventing them from competing with mammals and birds, which at that time possessed brains relatively no larger than those of the small dinosaurs. A general evolutionary trend toward higher intelligence can be described by a simple mathematical relationship* that suggests that neurological complexity may itself be the most important factor in bringing about further evolutionary increases in neurological complexity. Because of this general trend, and because of the existence of small brainy dinosaurs on our planet 75 million years ago, it is perhaps legitimate to speculate that they might have achieved human levels of neurological complexity had they survived the extinctions. One preliminary attempt has been made to deduce the appearance of such a creature.

We can discover a more general interpretation of the wealth of fossil debris in Dinosaur Provincial Park. It represents a gross experiment in evolution that was abruptly terminated. The modern world evolved from a restricted group of survivors from the dinosaurian world, and

is in part the result of another, quasi-independent experiment in evolution. The trends we can identify in the development of organisms that were exterminated at the end of the Age of Reptiles—and which also appear in organisms that replaced them—may represent trends in the evolution of life itself, whether on Earth or in the exotic biospheres of distant stellar systems. One of these trends seems directed toward the development of increasingly complex brains in some dinosaurs and in some mammals. If life pervades the cosmos, does it not everywhere struggle to ascend toward higher levels of complexity? The thought excites a sense of wonder for life and for living, and reflects a world we began to know, long ago when we were very young.

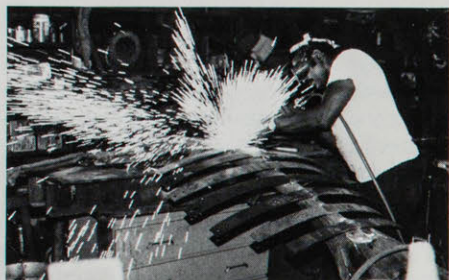
Dr. Russell is Chief of the Paleobiology Division at the National Museum of Natural Sciences in Ottawa. He has studied many collections of large fossil reptiles on this continent and in eastern and western Europe, including portions of the dinosaur collection of the Natural History Museum.

LIST OF DINOSAURIAN SPECIES FROM THE REGION OF DINOSAUR PROVINCIAL PARK, ALBERTA

- | | |
|---|---|
| I. Dromaeosauridae | VII. Hadrosauridae |
| 1. <i>Dromaeosaurus albertensis</i> | 14. <i>Kritosaurus notabilis</i> |
| II. Saurornithoididae | 15. <i>Prosaurolophus maximus</i> |
| 2. <i>Saurornitholestes langstoni</i> | 16. <i>Brachylophosaurus canadensis</i> |
| 3. <i>Stenonychosaurus inequalis</i> | 17. <i>Corythosaurus casuarius</i> |
| III. Oviraptoridae | 18. <i>Lambeosaurus lambei</i> |
| 4. <i>Macrophalangia canadensis</i> | 19. <i>Lambeosaurus magnicristatus</i> |
| IV. Ornithomimidae | 20. <i>Parasaurolophus walkeri</i> |
| 5. <i>Ornithomimus edmontonicus</i> | VIII. Nodosauridae |
| 6. <i>Dromiceiomimus samueli</i> | 21. <i>Panoplosaurus mirus</i> |
| 7. <i>Struthiomimus altus</i> | 22. <i>Panoplosaurus longiceps</i> |
| V. Tyrannosauridae | 23. <i>Panoplosaurus rugosidens</i> |
| 8. <i>Albertosaurus libratus</i> | IX. Ankylosauridae |
| 9. <i>Daspletosaurus torosus</i> | 24. <i>Euoplocephalus tutus</i> |
| VI. Pachycephalosauridae | X. Ceratopsidae |
| 10. <i>Stegoceras validus</i> | 25. <i>Monoclonius crassus</i> |
| 11. <i>Ornatolithus browni</i> | 26. <i>Centrosaurus apertus</i> |
| 12. <i>Gravitholus albertae</i> | 27. <i>Styracosaurus albertensis</i> |
| 13. <i>Pachycephalosaurus</i> ,
species undetermined | 28. <i>Eoceratops canadensis</i> |
| | 29. <i>Chasmosaurus belli</i> |
| | 30. <i>Chasmosaurus brevirostris</i> |
| | 31. <i>Chasmosaurus kaiseni</i> |

*The maximum size of the brain (after correcting for body size effects) attained by a terrestrial organism, at any time measured from one-half billion years ago, is proportional to the base of natural logarithms raised to the power of an observationally-determined constant multiplied by that time. For further information see Russell, D.A. "Exponential evolution: implications for intelligent extraterrestrial life" In: Holmquist, R. (editor), *Life Sciences and Space Research*, Pergamon Press Ltd., In press.

20th Century Dinosaurs Invade Los Angeles !!



Jim Gary at work in his studio.

The Natural History Museum has been invaded by "20th Century Dinosaurs!" and scrap metal animals. Led by a monstrous *Brontosaurus*, more than thirty creatures—half of them dinosaurs—have meandered up the Museum steps and are roaming through the Foyer. The imaginative and brilliantly colored beasts, created by New Jersey sculptor Jim Gary using discarded automobile parts, will inhabit the Museum through May 1, 1983.

In addition to *Brontosaurus* (42 feet long and composed of more than 500 individual car parts), the dinosaurs represented include a regal *Tyrannosaurus rex*, a flying *Pteranodon* with an 18-foot wing span, and a stunning *Dimetrodon* with an oil pan head, leaf spring ribs and sail, front-end suspension legs, and a tail of drive shafts and rocker arms.

Most of the car parts used by Mr. Gary are at least 15 years old; today's streamlined cars do not have the character he

finds in parts from older autos. It may take Gary up to a year to complete a major work, including weeks of research and visits to many automobile scrap yards to find just the right pieces. In talking about his work, Mr. Gary says,

"My sculptured animals represent a view of the past through the use of the discards of modern technology. I show this on four levels.

"First, my medium is the automobile and its parts, which I use because of the many parallels with extinct dinosaurs and reptiles. It appears to me that man used the prehistoric creatures as an engineering base for the air-breathing, gas-guzzling metal monsters of the road.

"Secondly, from the maze of mechanisms beneath the automobile shell, I have extracted animals. It is on this level that I show that the nuts and bolts—the basic wheels and pivots of our newest inventions—are the same as they were with nature's earliest machines.

"Thirdly, my animals have the ability to evoke childhood memories in adult viewers and at the same time give children a memory they will keep forever.

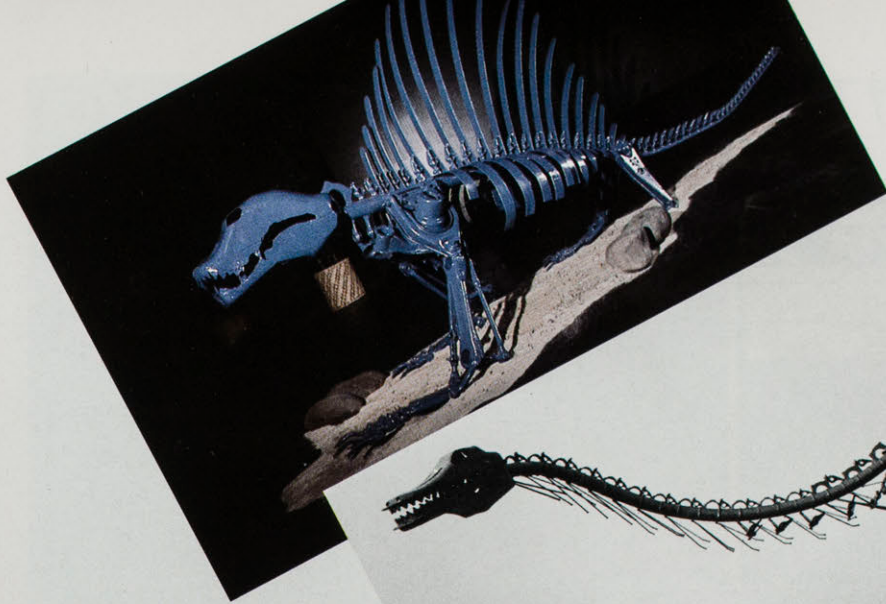
"Lastly, I hope I am making people aware of the many ways materials can be recycled and the importance of doing so in this day of diminishing resources. After all, reduced resources are requiring engineers to

design more efficient cars just as a changing environment once caused the large clumsy dinosaurs to change or disappear."

Mr. Gary has received national recognition in such publications as *National Geographic World* and the *New York Times*. His sculptures have recently been viewed by enthusiastic audiences at the Carnegie Museum of Natural History in Pittsburgh and The Children's Museum in Indianapolis.

DINOSAUR DAYS AT THE NATURAL HISTORY MUSEUM

The "20th Century Dinosaurs" inhabiting the Museum from January 29 through May 1, 1983, provide the setting for **DINOSAUR DAYS**, a three-month extravaganza of programs and events related to these ancient reptiles. Dinosaur Saturdays, Tours, a Youth Workshop, Films, an In-Service Course for teachers, a "Build a Better Dinosaur Contest" and two Dinosaur lecture series will be among the events offered. Look for your special Dinosaur brochure or call the **DINOSAUR HOTLINE: 744-3426** for details!



TRACKWAYS

CLUES TO PASSING DINOSAURS

Photographs by the author.

by KENNETH E. CAMPBELL

High on the side of a mountain in a remote corner of central Bolivia lies a small but important clue to the mysterious history of dinosaurs. Preserved at a site known as Toro Toro, named after a nearby Andean village, are numerous fossil trackways left by a wide variety of passing dinosaurs of all sizes. The footprints are found preserved in several layers of hard late Cretaceous siltstones and mudstones, 80 to 90 million years old. They range in size from less than six inches (25 cm) to more than twenty inches (80 cm) in length, and may be found almost wherever one looks. Walking among these abundant trackways one cannot help but feel the presence of the dinosaurs that left them millions of years ago.

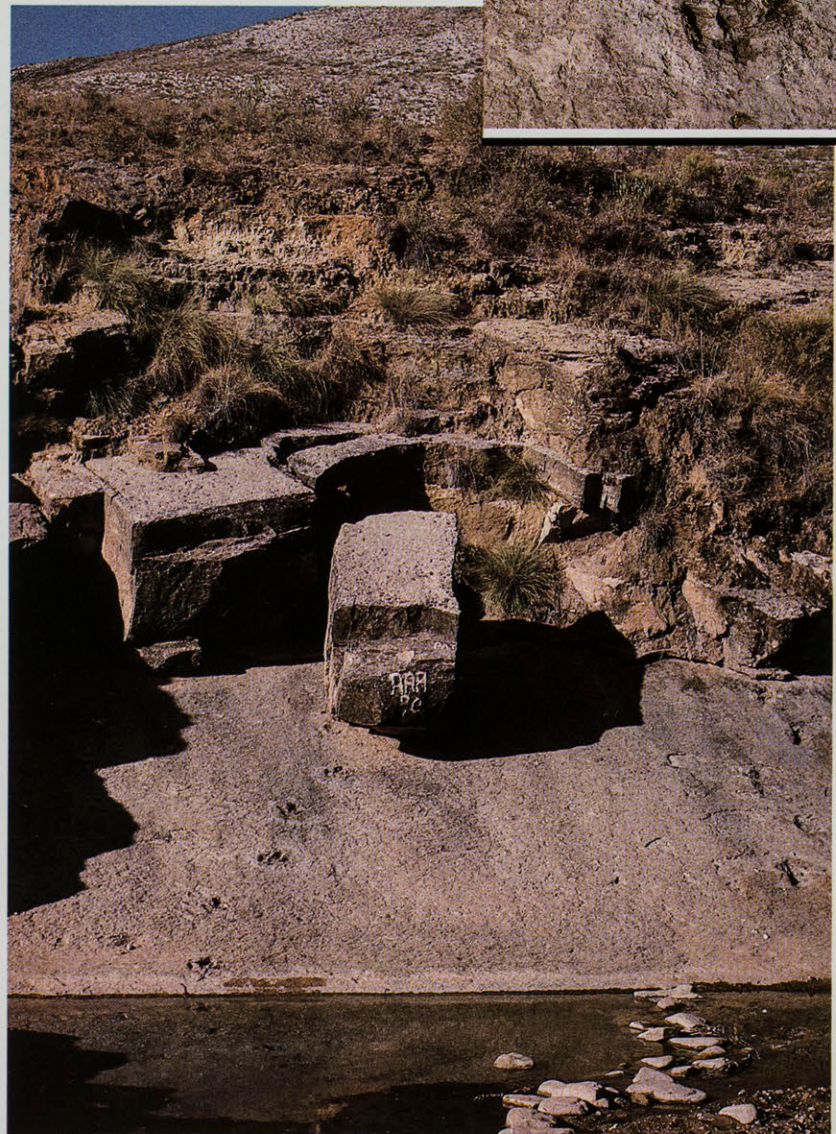
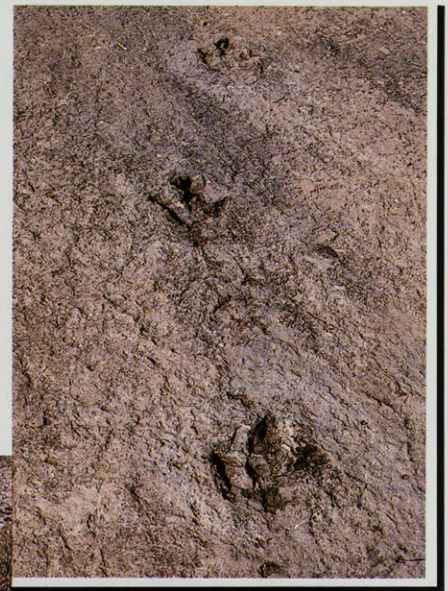
The most spectacular of the trackways present at Toro Toro was left by a giant sauropod. The total length of this impressive trackway is almost 100 feet (30 m). The large sauropod footprints are over one foot (35 cm) deep at one end of the trackway and gradually become shallower until they disappear at the opposite end of the trackway. This may indicate that the sauropod was walking through rather soft mud that gradually became firm enough to support the ponderous dinosaur, whose weight may have exceeded twenty tons! Or, the sauropod may have been wading into deeper and deeper water, and the buoyancy of the water may have supported more and more of its weight, thereby keeping it from sinking as deeply into the mud.

No fossil bones of dinosaurs have ever been found in Bolivia, and the dinosaur trackways at Toro Toro are the only ones known from that country. And the sauropod trackway is the only one known from South America. So although the trackways of Toro Toro are still relatively unknown except to local villagers and Bolivian scientists, they are of considerable international paleontological interest, representing as they do a solid clue to the presence of the mysterious dinosaurs in a part of the world where so little of their history is known.

Dr. Kenneth E. Campbell is Curator of Vertebrate Paleontology at the Natural History Museum. His work on the geology and vertebrate paleontology of Bolivia have taken him to many parts of that country (TERRA, Spring, 1982).

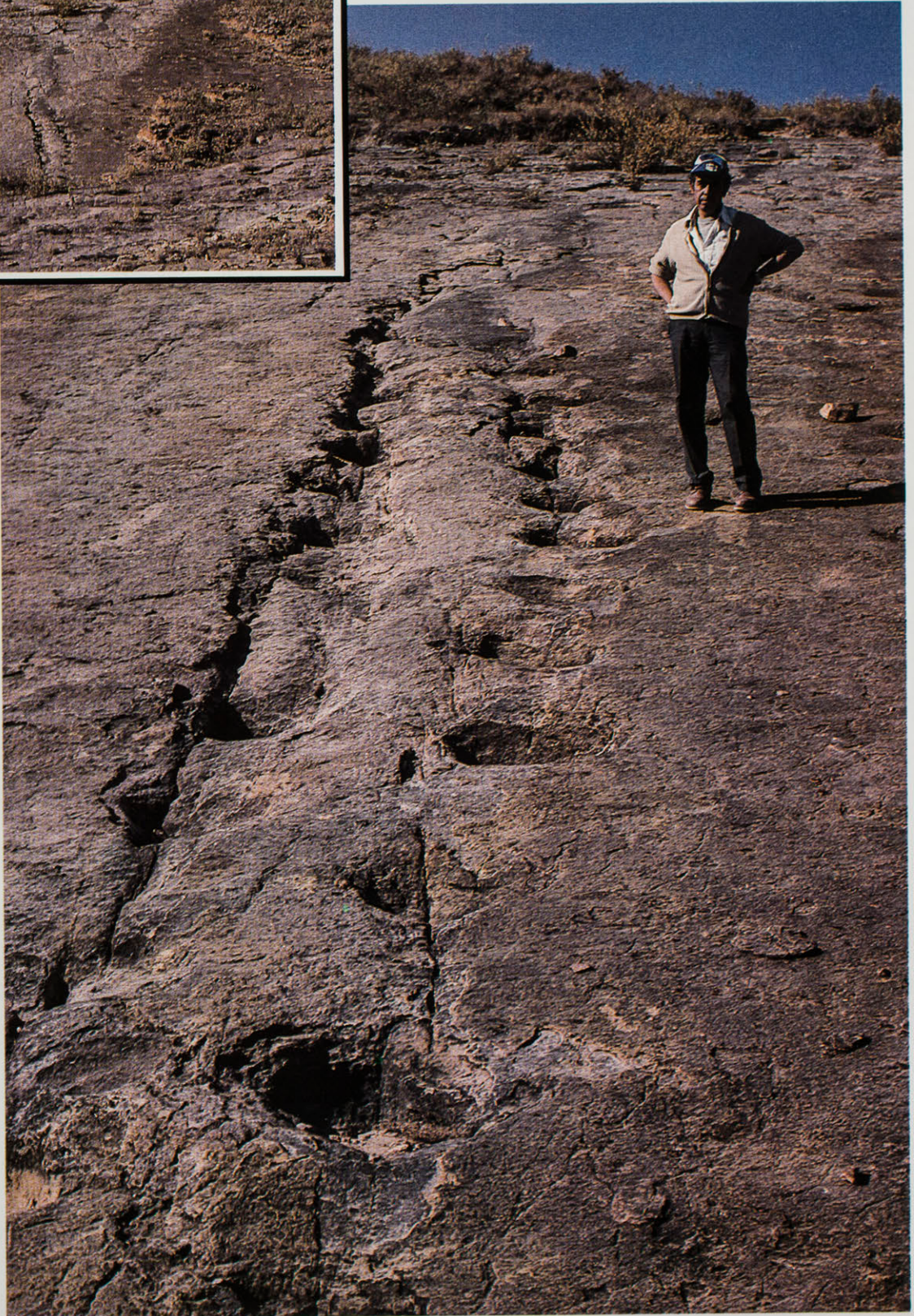
Below: Trackways of two bipedal dinosaurs appear on this exposed slab of rock, one on each side of the photograph. Both trackways are covered at each end. Most of the different layers of rock exposed in the background contain dinosaur trackways and isolated footprints.

Inset: Three of the eight exposed footprints of the trackway on the left are shown here. Each footprint is about one foot (30 cm) long.



Below: This spectacular trackway at Toro Toro, Bolivia, is one of the best late Cretaceous sauropod trackways known, and the only one known from South America. Ing. Raul Carrasco of the Servicio Geológico de Bolivia, shown in the photograph, accompanied the author and Dr. David Frailey of Midland College, Texas, on an arduous 2-day journey to reach the remote site during a paleontological expedition to Bolivia in July, 1982.

Inset: The sauropod footprints are shown here from a distance. Local villagers have cleared the vegetation and soil from over much of the trackway, although they still disappear under the soil at the bottom of the slope where they continue for an unknown distance.



A MUSHROOMING INTEREST

by FLORENCE H. NISHIDA

Photographs by the author

14 Gather a few people around a wet log in our oak woods to point out a shimmery, amorphous glob of orange "witches' butter," and some daring person will tap it cautiously, reacting with a surprised "Ooh!" at the sensation, until finally everyone has poked and prodded *Tremella mesenterica*, a jelly fungus very distantly akin to the common gilled mushroom. People's responses to mushrooms are never lukewarm. There is either an undiluted fascination or an undisguised reaction of horror and distaste. And efforts by the mycophobic (people fearful of mushrooms) to rid gardens of "toadstools" reveal a lack of understanding about fungi. Mowing down a stand of mushrooms is a fairly good way of dispersing the organism, rather than of stifling it. One source of confusion is not realizing that the car-

pophores (mushrooms)—whether they arise from a stump in the woods, in carpet-like profusion in a commercial mushroom farm, or from heaps of decomposing forest litter—are actually the fruiting bodies and not the entire "plant."

Mushrooms are fleshy members of the large group of simple, nonflowering plants of the kingdom, fungi. They seem mysterious, because in a sense they are seasonally appearing fruiting parts of perennial plants that remain hidden underground or buried in wood. The onset of cool, wet weather provides water—the single most important prompter for the fungus to begin production of the mushroom fruit body whose purpose is to create the possibility of another generation by releasing minute particles, known as *spores*, into an hospitable (humid) environment. One mushroom,

Astraeus hygrometricus, is so attuned to this moisture requirement that it opens and closes its thick outer rays in response to changes in humidity, even after being plucked from the field and brought into the lab.

The mushroom "plant," that portion underground, is a mass of tangled, undifferentiated, fine, thread-like cells, forming the vegetative body, or *mycelium*. While lacking roots and vascular structures, the mycelium produces enzymes that dissolve larger compounds in the soil or other substrates such as wood, leaf litter, even plaster walls, into components that can be utilized as food. Mycelium is capable of traveling great distances to obtain food. Fruit farmers dread the sight of *Armillariella mellea* (the "honey mushroom" to mycoph-



Geastrum triplex. An "earthstar" fungus whose outer thick peridium protects spores, then cracks open to permit their dispersal. The peridial rays often fold back to elevate the spore case.



Mushroom "bumps." Mushroom hunters of semi-arid places like southern California often have to seek their fungi by looking for bumps formed by the expanding mushroom, which may lie under several inches of humus and leaf litter.



Collybia sp., a "typical" mushroom with cap, gills, and stem. Its growth habit is cespitose (clustered at the base), a characteristic of many mushrooms that grow out of wood.

gists, people who enjoy mushrooms as food), because it can invade and parasitize trees hundreds of yards away. One wonders about the fate of a new apartment building in West Los Angeles with a glorious fruiting last spring of this fungus near its foundation.

When conditions are right (periodically for some species, once in forty years for another), tiny nodes or bumps form in the mycelium. As these absorb water and nutrients and expand their cells, they push their way up, usually toward light (they are phototropic), from depths as great as two feet, through humus, wood, even hard-packed soil, or from beneath concrete or asphalt. If they emerge from their substrate sideways, the *stipe* (stem) will curve upward to a perpendicular position so that the cap is positioned over the ground (mushrooms are also geotropic). They emerge, exposing their spore-bearing surfaces for the liberation of a billion or more spores from one mushroom alone. Of the astounding number of spores dispersed into the environment, only a tiny percentage germinates, because so many alight on unsuitable and exposed areas. The spore germ tube enlarges, branches, and develops into a tangled mass of primary mycelium. Upon meeting another mycelium with which it has mating compatibility, it merges to form the secondary mycelium from which arise the primordial nodes

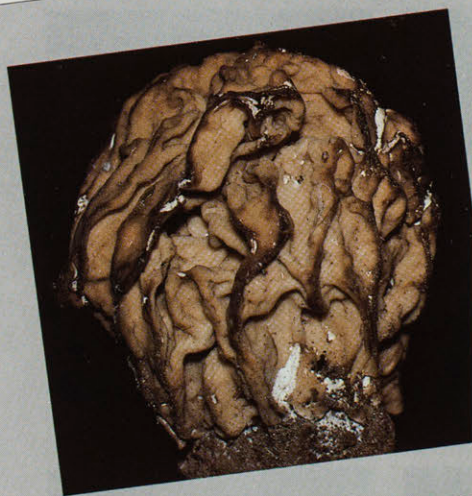
of mushroom fruit bodies, starting the cycle again.

Mycologists (scientists who study fungi) classify the fleshy fungi, commonly known as mushrooms, based upon the type of reproductive structure found in the fruiting body. The mycelia of several different species can be found in a particular location and are often indistinguishable from each other. Classification, and therefore the naming of mushrooms, is based practically solely on our understanding of the seasonally appearing fruit. And as their appearance is much less dependable and predictable than, say, the fruiting of an apple tree, the mushroom hunter and student is frequently frustrated, but always intrigued. Ascomycetes is a large class of fungal species, mostly too small or inconspicuous to be of interest to the mushroom hunter. But the class of Basidiomycetes contains the greater portion of mushrooms and "toadstools" (the English common name for a poisonous or disagreeable fungus). Fleshy and conspicuous ascomycetes, which might be considered mushrooms, are frequently cup-shaped or are stalked structures with folded and convoluted caps. The exposed cap surfaces are lined with sac-like cells of mi-

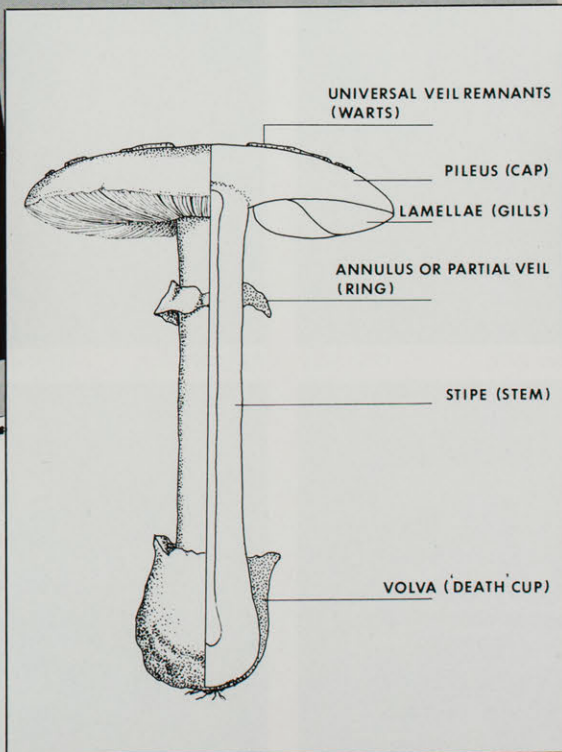
croscopic size, termed the *asci* (singular: *ascus*), which bear spores internally. In the basidiomycetes, spores are borne externally, at the ends of fine projections arising from the respective cells, termed the *basidia* (singular: *basidium*).

A great variety of morphological types can be found among the basidiomycetes, the richness and uniqueness of these forms perhaps representing a variety of strategies for the optimum production of spores, for their effective dispersal, and for their protection during maturation and periods of environmental stress. The traditional "mushroom" is a fungus of the order Agaricales, having basidia and spore bearing *gills* beneath an umbrella shaped, protective cap. The *stipe* expands, sometimes in hours, to elevate the cap for maximum distance in wind dispersal of spores. Enveloping membranes can be found among certain species, particularly in one genus, *Amanita*, whose fragmented remnants appear as flecks or warts on cap tops and as a *volva* (cup, "death cup") at the base of the stipe. Many mushroom species have developed a partial membranous sheathing between the cap and stipe only, which acts to keep

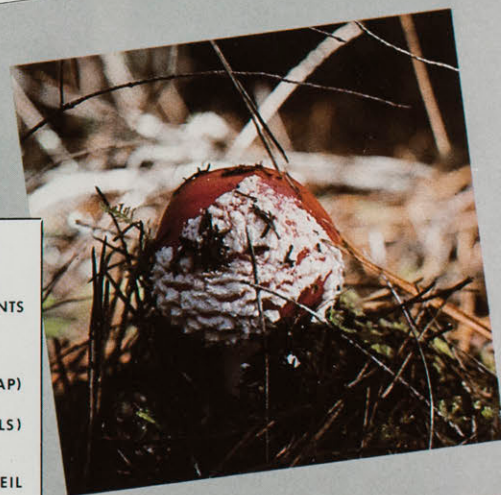
(Continued on page 18)



Gyromitra esculenta, an ascomycete that appears to have genetically different populations. Long eaten in Europe ("esculenta" means edible) until several deaths were attributed to it, the species is still collected for the table in the Pacific United States, where it has thus far not caused poisonings.



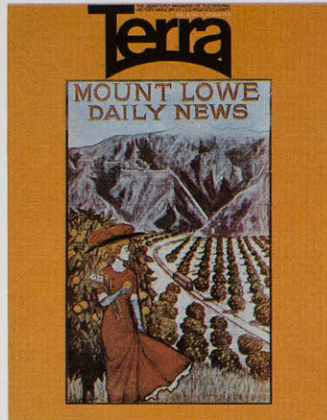
A composite drawing of the "traditional" gilled mushroom.



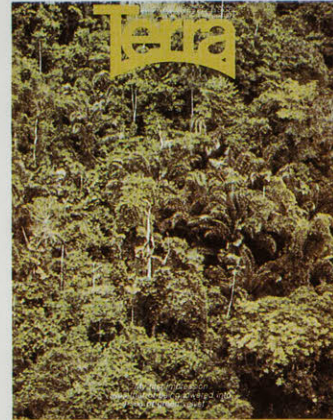
Amanita muscaria. The universal veil of this toxic (but probably not fatally so) mushroom is apparent here on the expanding cap. Careless collecting often leaves the volva, a distinguishing mark of the genus, in the ground, thereby causing misidentification.



Fall 1970



Spring 1971



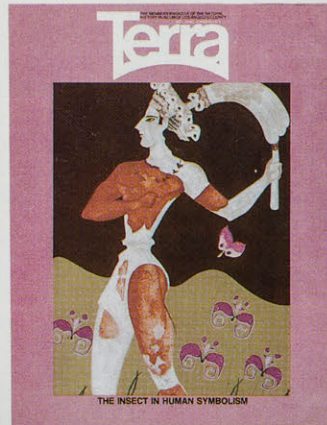
Spring 1972



Spring 1973



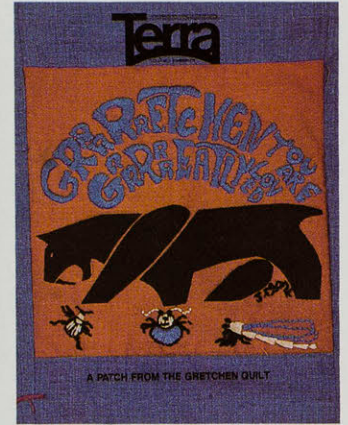
Fall 1974



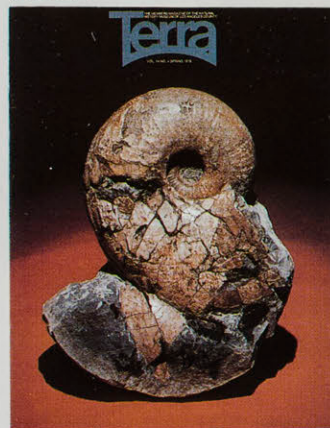
Winter 1975



Spring 1975



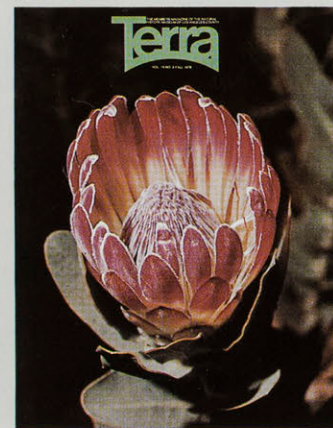
Summer 1975



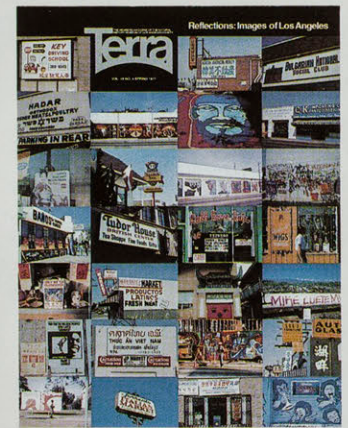
Spring 1976



Summer 1976



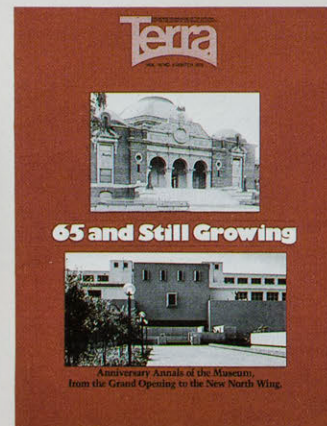
Fall 1976



Spring 1977



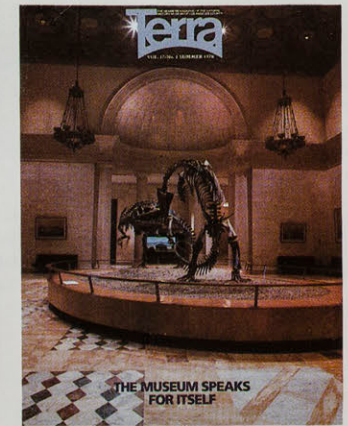
Fall 1977



Winter 1978



Spring 1978



Summer 1978

TERRA MAGAZINE, 1970 TO 1982

With the publication of the Winter 1983 issue of TERRA, our Editor, Dorothy Seligman, is retiring. Dorothy has served the Museum and the membership for seventeen years beginning in 1965 as Editor for the Quarterly and later for its successor TERRA. For most of these years Dorothy served as a volunteer. She developed a dedicated and gifted group of associates on the magazine's Editorial Board, and together they produced an excellent Museum publication. From 1974 to 1977 TERRA won an Outstanding Design Award from the Printing Industries of America.

Although Dorothy has decided it is time to retire as Editor she has agreed to continue to serve in an advisory capacity. We all owe Dorothy and the members of the Editorial Board a tremendous debt of gratitude for their service, for which they have my heartfelt thanks.

I look forward to continuing the tradition of excellence which Dorothy and the members of the Editorial Board have brought to TERRA and to building an even stronger magazine for our membership and the Museum's public in the future.

Craig C. Black, Director
Natural History Museum



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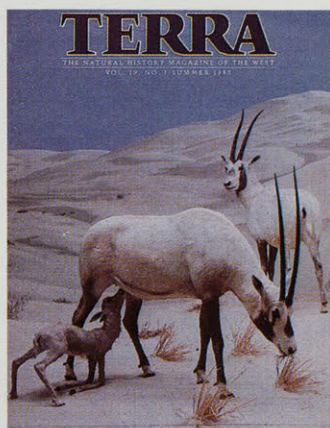
Fall 1978



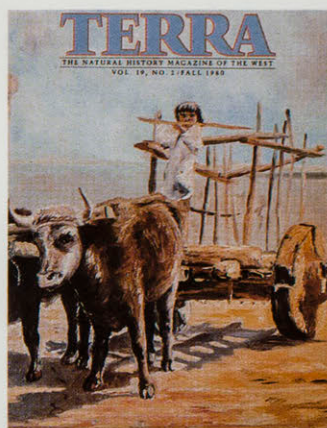
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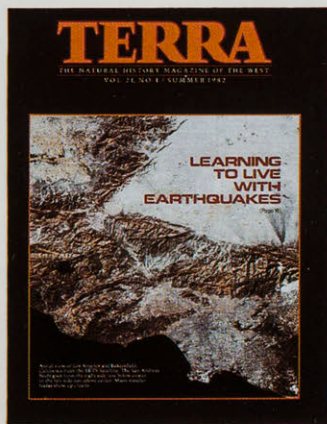
Summer 1981



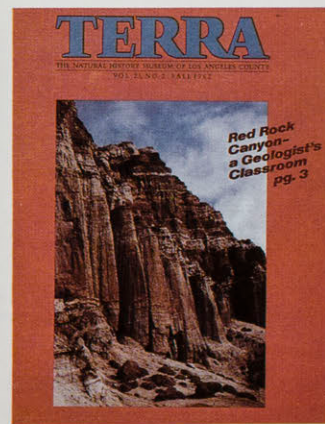
Fall 1981



Winter 1982



Summer 1982



Fall 1982

gills and maturing spores tightly appressed in a moist chamber until maturation of spores occurs. The fragmented remains of this partial *veil* can be seen as a "ring" around the stipe.

Non-gilled mushrooms such as "boletes" (family Boletaceae), which have caps and stipes, as well as "polypores" (several genera of the order Aphyllophorales), which have shelflike or at least stipeless shapes, closely pack the area beneath the cap with spore-bearing tubes rather than with widely spaced gills, so that fertile surfaces are arranged with greater density. Members of the family Hydnaceae take an opposite approach—long spines or shorter teeth extend the surface area of the fertile layer beneath the cap. "Puffballs," the genera *Calvatia*, *Lycoperdon*, *Geastrum*, and others, develop and mature their spores within a completely enclosed case, the *exoperidium*. Some peridia become papery when mature, easily tearing; some are thick and leathery and crack into lobes or rays; some develop pores through which puffs of spores escape over a long period of time when struck by raindrops or passing animals. Coral fungi have evolved forms as simple as the club shaped *Clavariadelphus pistillaris* as well as multiple branching forms such as those in the genera *Ramaria* and *Clavaria*, which greatly enlarge the potential fertile areas. Both corals and puffballs are eagerly sought by collectors because, with attention to certain details, both groups are relatively safe to collect for the table. A recent collection of a forty-pound *Calvatia booniana*, the "western giant puffball," having been rejected for serving at a local French restaurant because it had passed its eating prime,

now sits drying outside the Museum botany laboratory window.

Mushroom hunting has much in common with fishing. Previous knowledge of rainfall, temperature, and amount of sunshine and use of favorite haunts rarely insure success in collecting. One year a "rare" mushroom may make an appearance and a "weed" species may disappear. As dependent upon rainfall as mushrooms are, they are nevertheless rare in tropical rain forests, which have very little humus or litter, and also during excessively wet and cold periods here in southern California. But some understanding of the role of fungi in the ecosystem can provide clues as to why and where to find them.

As mushrooms lack chlorophyll and are unable to manufacture their own food, their survival is based on three methods of obtaining nutrients; parasitism, saprophytism (decomposition), and mycorrhizae formation (symbiosis). Long maligned due to superstition, few mushrooms are actually important as parasites. More commonly, a "conk" or bracket fungus found on a dead tree has opportunistically come in when the tree was diseased or weakened and is contributing to its decomposition, returning it to nature. Deciduous leaf litter, broken branches, dead annual plants are all intertwined with hard-working saprophytic fungi. They are also responsible for the "fairy-ring" in city lawns and parks. Indeed, their appearance is perhaps the most predictable. Each rainy season promotes fruiting of these fungi (*Marasmius oreades*, *Chlorophyllum molybdites*, and species of *agaricus*) at the continually

growing edge of the mycelium, which radiates outwardly to locate new root debris and litter in the soil. In undisturbed grasslands in Kansas, fairy rings of meadow mushrooms and puffballs have been found as large as 600 feet in diameter. In England, large fairy rings near Stonehenge have been estimated to be several centuries old. Other saprophytic mushrooms can be found closer to home. A recent flooded basement floor in this writer's home brought forth a carpeting of tan, fluted cup fungi, well named *Peziza domiciliana*, as it decomposes plaster and textiles. The bright yellow drumstick-shaped mushroom, *Leucocoprinus birnbaumii*, often springs up with houseplants, having hitchhiked to the city in redwood bark.

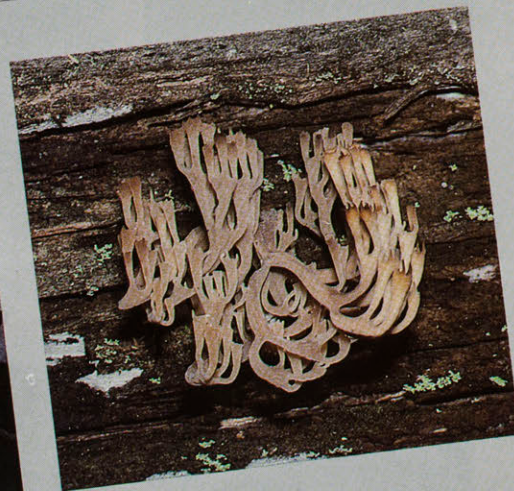
The most significant role of mushrooms appears to be that of mycorrhizae formation in a symbiosis greatly beneficial to the health of higher plants such as pines, firs, spruces, oaks, and aspens, as well as essential to the existence of the mushroom. The higher plant and the fungus are actually in close association at the fine rootlets (this being the mycorrhizae formation), where products derived through photosynthesis by the higher plant and needed minerals derived from the soil by the fungus are exchanged. The fungus is invisible for most of the year, since mushrooms, being ninety-seven per cent water, are highly dependent for their very appearance on the whims of weather. The fruiting bodies appear seasonally while the vegetative and mycorrhizae forming portion is perennial though hidden below the sur-



Boletus sp. A bolete with reddish tube mouths or pores, collected in Arizona under Gambel oak. Poisonous boletes are often found among the red-pored species. Boletes are fleshy mushrooms that have stipes and are different from the leathery, woody, or corky and generally stipeless polypores.



Hericium ramosum, a member of the dentate or spiny family, Hydnaceae. It is found on live oak, where it may fruit more than one season.



Clavicornia pyxidata and *Ramaria* sp., (page 19, left). These are "coral" fungi with numerous branching arms which increase fertile surface area. Often only their brilliantly colored tips are visible in pine needle litter.

TAKE A SECOND LOOK

Look-alike mushrooms require a second look. These at first glance both have an overall whitish color, smooth and generally convex cap, a partial veil (ring on the stipe), pallid gills, and a white spore deposit. But the "volva" or cup at the base of the stem, remnant of the universal veil or enveloping membrane, on the mushroom at the left is of taxonomic importance for the genus *Amanita*. Ignorance of this feature could have grave consequences for a careless collector who pulled the mushroom out of the ground, leaving the volva behind. The genus *Amanita* has the greatest number of

deadly poisonous mushrooms.

On the left is *Amanita phalloides*. This species and pure white *A. verna*, *A. virosa*, and the common southern California woodland species, *A. ocreata* (sometimes orange-tinged), are very similar in appearance, and all are deadly. Remnants of the universal veil on the cap of *Amanita phalloides* and *A. ocreata* are often very scanty and easily lost during heavy rains, misleading a collector by their absence.

To the right is *Lepiota naucina*, which usually occurs in lawns, has no remnants on the cap nor a volva at the base, and is edible.



Watercolor by Mary Butler, Museum Illustrator

face of the ground. There are estimates that as many as sixty per cent of all mushrooms are mycorrhizal. Certain known mycorrhizae formers are being inoculated into nursery stock of conifers, suggesting a new attitude toward mushrooms beyond their appreciation as colorful and decorative members of a plant community or merely as forage foods.

Yes, but is it edible? Rarely is the taxonomy of natural objects so linked with gastronomy as in the case of mushrooms and the public. And possibly only a herpetologist hears "Is it poisonous?" as frequently as a mycologist does. Neither extreme view contributes to understanding—that of a recent Museum Open House visitor who admonished his daughter—"Wash your hands. You touched that mushroom"; or that of the casual forager who picked through a jumbled heap of mushrooms, tossing out an occasional one over his shoulder because it "didn't look right." No generalization is applicable in determining the edibility of mushrooms. And the great danger of applying even first-hand knowledge to a different geographical location was demonstrated this spring in the worst incident of mushroom poisoning in San Diego history. Three serious cases of

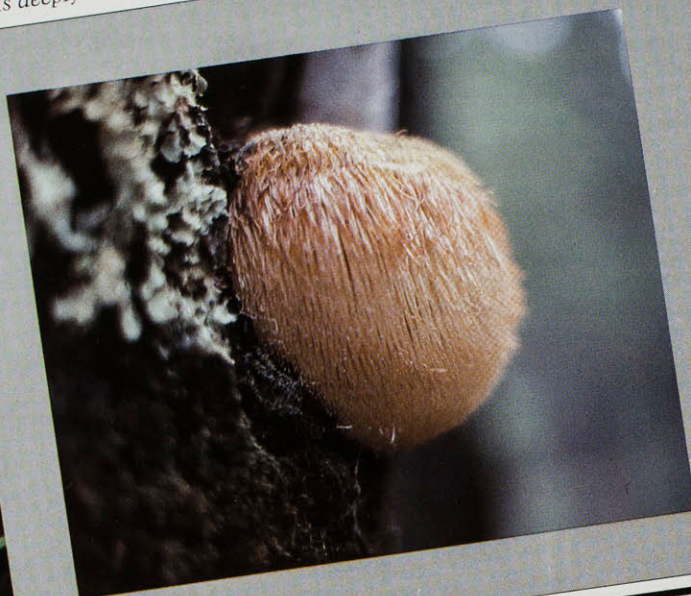


Calvatia booniana ("western giant puffball"), which typically grows 12 to 20 inches long in dry, open coniferous forests. Several pure white puffball steaks can be cut from one mushroom. Piles of chocolate brown, fine, powdery spores often remain from previous years.

Ganoderma tsugae. A polypore or a "shelf" fungus distinguished by a varnished appearing cap, tubes—rather than gills—carrying spores, in a conifer wood habitat.

Lactarius resimus. *Lactarius* species exude a liquid when injured on the gills. The color, variability, and staining effects of these mushrooms are of taxonomic importance. Many *lactarii* are very peppery in taste.

Hericium erinaceus. "Bear's Head" fungus is often found on oak. Its spores are formed on the numerous, fleshy, pendulous "teeth," while its tough base is deeply rooted in the tree.



Boletus edulis ("Cep" or "Porcini" in Europe). These large, firm-textured, nutty flavored choice mushrooms are more common from Santa Barbara northward. They are mycorrhizal with oaks and conifers. Drawing by Frances Runyan.

poisoning among Laotians resulted from the ingestion of mushrooms, still unidentified. They reportedly boiled the mushrooms with rice as they had in their homeland to see whether the rice changed color and become red. The mushrooms in southern California passed the test, but the test was a complete failure. *Amanita ocreata*, a deadly species, and its northern California companion, *Amanita phalloides*, are very common inhabitants of the oak woods. *A. ocreata*, an all-white mushroom of classic proportions, has a white cap tinged with a faint metallic green when fresh. Its variability of color (yellow to orange), its beauty and abundance, added to careless or over-confident

identification, has caused at least eight deaths in California in the 1981-1982 season.

However, mycophobia is an over-reaction in view of the facts. Of almost 5,000 North American mushroom species, fewer than a dozen relatively common species are serious poisoners. The vast majority are harmless, and even

in arid southern California woods, a surprising number are edible, and several are choice, well-known, and collected throughout the world. They are generally mycorrhizal here with *Quercus agrifolia*, the coast live oak. While mushrooms in Europe are now in danger of reduction in numbers due to over-collecting and damage to mycelia, mushrooms in the Los Angeles area are endangered by the same threat to many natural species—urbanization of the oak woodlands.

Still, the taste of wild mushrooms is at hand. From the first cool, rainy days of fall when *Laetiporus sulphureus* ("sulphur shelf") fruits on the eucalyptus trees

(Continued on page 22)

WILD MUSHROOMS IN THE MUSEUM

"Mushrooms Up and Down Los Angeles," a new Botany Section exhibit opens on the second floor on 27 March 1983, featuring the wild mushrooms that a resident of Los Angeles is most likely to encounter. Common species of urban, woodland, and nearby pine forest areas are represented by photographs and models, with descriptions referring to habitat (ecological) relationships, edibility, and toxicity. The exhibit is organized around the theme by Florence H. Nishida, Museum Associate in Mycology, who has been collecting and examining mushrooms of Los Angeles for the Museum herbarium.

Photographs taken by Dr. Harry D. Thiers, of the Biology Department at San Francisco State University, will provide the core of the exhibit, and he will give a talk on opening day of the exhibit on Sunday, 2:00 p.m. in the second floor mammal hall, elaborating on mushrooms of California. Dr. Thiers' extensive collecting and study of mushrooms in this state, since 1968, particularly in northern California and the Sierra Nevada Mountains, as well as frequent forays to the Rocky Mountains, make him the recognized authority in California mushrooms. A highly esteemed agaric mycologist, student of Alexander H. Smith of Michigan, and himself responsible for the training of many fine mycologists across the United States, he has undertaken the publication of a long awaited series, The Agaricales (Gilled Fungi) of California, (Mad River Press, Eureka, California). The first of the series, Amanitaceae, written by Dr. Thiers, is already available. Future numbers will have the same fine features: loose leaf format for later inclusions; excellent color photographs; thorough descriptions, including microscopic features; and notes on distribution.

Dr. Thiers has given generous support to the San Francisco Mycological Society to whom he has been scientific advisor. A similar amateur society of people interested in mushrooms, the Los Angeles Mycological Society, formerly based at the Natural History Museum, now meets at Cal State Los Angeles under the sponsorship of Dr. Daniel Maboney, of the Biology Department. Questions concerning local mushrooms, books, and the society may be directed to Florence Nishida in the Botany Section at the Museum.

Cantharellus cibarius ("chanterelle"), known and beloved world wide for its beauty, apricot aroma, firm texture (nearly always insect-free), and unique flavor.



Agaricus rodmani, a close relative of the market mushroom, *A. bisporus*, but superior in size, firmness, and flavor. It is very fond of hard-packed soil and frequently breaks through asphalt paving or out of the middle of well-used paths.



(Continued from page 20)

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by the old east entrance to the Natural History Museum, and lawns and parkways are sprinkled with edible *Marasmius oreades*, occasional *Agaricus campestris* (the "champignon") interspersed with the poisonous *Agaricus xanthodermus* (the "yellow stainer"), one can collect mushrooms somewhere in the greater Los Angeles area nearly every weekend of the wet season except for periods of drying Santa Ana winds. The saprophytes generally appear earliest, specially when aided by regular watering such as occurs in urban areas. They are the most nearly reliable in appearance, at times fruiting two to several times a season, nearly crop-like. And many saprophytes reappear annually in the same place. *Hericium erinaceus* ("bear's head"), a compact, abalone-textured mound with great, long soft white spines, can be collected on the same tree from year to year. People visit their *Lepiota rachodes* patches every two to three weeks to collect this large, meaty mushroom. Owners of Monterey pines more often than not discover *Suillus granulatus*, an edible boleta, growing in the needle litter. The all purple blewitt, *Clitocybe nuda*, is a welcome sight in oak leaf piles.

Then, the establishment of winter rains produces the fruiting of the best, and of many mycorrhizal species as well: *Boletus edulis* ("Cep" or "Porcini"), which looks like a great, lightly-browned bun on a stout leg; *Cantharellus cibarius*

("chanterelles"), a golden orange fluted mushroom that reaches eight to twelve inches in diameter, weighs from one to three pounds, and is redolent with the aroma of apricot; *Agaricus arvensis* (the "horse mushroom"), with a rich bronze color and strong, almond-extract odor and taste. Later, warmer spring weather brings out morels in widely scattered parts of the city. Construction sites and large planters produce surprising numbers. Melting snow at higher elevations in the San Gabriel and San Bernardino mountains also provides morels and edible puffballs.

Some species attract our interest apart from gastronomical reasons. *Omphalotus olivascens*, an orange, trumpet-shaped parasite or saprophyte can mimic chanterelles, but causes severe gastro-intestinal distress if eaten. Reputed to glow in the dark, it is nicknamed "Jack o' lantern." The reasons for bioluminescence, toxicity, even color, are not clearly understood. Experiments with rats and acrid mushrooms have shown that rodents are capable of learning to recognize and thus avoid disagreeable mushrooms. Would this enhance the survival of the mushroom species? Yet, rodents are also a very effective, perhaps even the principal, dispersal instrument for most hypogeous (underground) fungi such as truffles, which have very distinctive and powerful attracting odors. The peculiar fungi of the order Phallales are also quite effective in utilizing odor to attract insects. Many species occur in tropical areas, frequently in a high degree of shade. Their

spore mass is contained in a wet, sticky, dark green, exposed *gleba*, which has an overwhelming, fetid odor, very attractive to flies, which then become dispersers of the fungus.

Mushrooms are a vital part of the ecosystem. As decomposers, they are tireless in aiding the return of dead plant material into a usable organic substrate capable of trapping and keeping water; as mycorrhizae formers, they direct minerals to higher plants. A recent sight brought home the inescapable connections among living things.

A steady stream of ants marched between a brightly colored *Russula veternosa* and an enormous oak tree growing overhead. At first, it appeared that the ants were carrying chunks of mushroom, a bit of insect foraging. But a closer look revealed that the ants were carrying larvae with which the mushroom was riddled (a case of insects hatching and residing in a fungal home). The ants moved up and down the tree, which housed them and their cache of food. The mushroom was now crumbling and beetles would probably arrive to carry off the remains, but it had begun in a partnership with the oak tree and was now being dispersed by insects.

Florence Nishida is a Museum Associate in the Botany Section of the Natural History Museum and a former president of the Los Angeles Mycological Society. Her current projects are Basidiomycetes of the Pacific Basin Islands and mushrooms of the Southwest.

Through a Maze of Mushroom Guides

by DON R. REYNOLDS

How can you tell if that mushroom growing in the lawn is poisonous? This is the question frequently asked at the Botany mushroom display by Museum Alliance members during the Annual Open House.

Curiously the "pothunter" interest in finding mushrooms to satisfy one's culinary desires grows into a passion for naming each and every mushroom found in the lawn and the woods. The resulting need is for a reference that an interested person can use to identify mushrooms and other conspicuous fungi. But accurate name giving is not easy. And the name givers are of two sorts—professional and... well, questionable, to be kind.

A professional mycologist develops a concept of the species based on an understanding of biological principles and on measured observations of mushroom characteristics. The mushroom species concept is ideally realized by the careful study of many examples. Once the species concept has been defined, some rules must be followed in giving a name. These regulations are found in a code that is legislated by an international body of plant taxonomists.

A widespread complaint of the pothunter, as well as the scientists who study aspects of mushrooms other than taxonomy, is that mycologists are constantly changing the names of mushrooms. Change is part of the scientific process and results from periodic reevaluation of data and studies of larger samples of mushrooms from more places with better techniques. New information about a certain mushroom may lead to its being reclassified and given a new or partially new name. The professional mycologist understandably devotes time to documenting scientific work with publication of name changes in technical journals. A few of these professionals also translate technical work into field guides for the mushroomer.

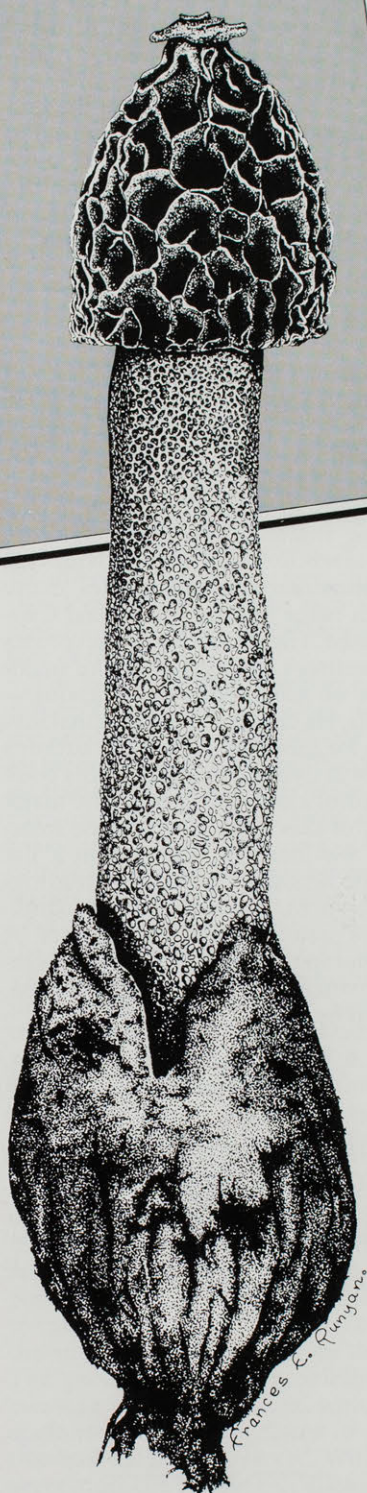
The need for easy to use and up to date

field guides to mushrooms has also led to the publication of books by self-taught pothunters. Roaming these United States is a cadre of naturalist "experts" who seem to be devoted only to mushrooms. They gain their species experience through observing mushrooms in the field and eating those that they find. Occasionally they rub elbows with professional mycologists, often at group searches for mushrooms called "forays." Some of these well-meaning naturalists have made it into print with regional guides to mushroom species. The pitfall of relying exclusively on some of these popular books is that identifications may be carelessly or too quickly made, with possibly serious consequences if the mushroom in question is to be eaten.

Then how does one recognize a good basic field reference for the identification and eating of mushrooms. I suggest that the user do the following. Determine the credentials of the author—does the person have documented experience with the subject? Examine the book carefully: does it clearly depict the mushrooms with good descriptions that are easy to use in the field, as well with as brief summary of those characters used in the laboratory? Does the author give reference to the technical literature? Do the illustrations clearly show basic details. Does the book apply in the region in which the mushrooms are to be found? The mushroom book that is most useful will also discuss the human usefulness of the species. Recipes for edible species are a bonus.

Several mushroom books are available in the Museum bookstore. The annotated list that follows ranks the references following the criteria mentioned above. Five mushrooms means that it is the best available. Three mushrooms means take your chances and check it out. One mushroom means that, in my opinion, it should not even be used in the supermarket.

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Phallus impudicus, a member of the Order Phallales. These mushrooms are attractive to flies, which disperse the spores, but a repugnant sight to the easily alarmed: one woman in Long Beach called the police to report their presence in her garden. Drawing by Frances Runyan.

THE AGARICALES (GILLED FUNGI) OF CALIFORNIA. 1. Amanitaceae. H. D. Thiers. 1982. Mad River Press. \$4.45.

This is the first chapter in the definitive work on the mushrooms of California. The first part includes a key to families of the gilled fungi, to the genera of the family Amanitaceae and to the species in this family. Each species is fully described, with reference to important sources of information; characters that are important for field identification are discussed in comparison with those of other species. The color plates are excellent. Dr. Thiers is an authority on California mushrooms and is serving as editor for this work. Each genus will be published as the experts write it. Needless to say, the mushrooms that will first be treated in this series are those for which there are experts. One future chapter is to be on the genus *Agaricus*; the author will be R. Kerrigan who carried out research on this genus as a Master's student under Dr. Thiers.

A FIELD GUIDE TO WESTERN MUSHROOMS. A. H. Smith. 1975. The University of Michigan Press. \$16.50.

Anything written by Alexander Smith for amateur mushroomers should be used as a reference with confidence. This field guide is an offshoot of the popular *Mushroom Hunter's Field Guide*. The western species discussed in this guide represent many to be found in southern California. Each species is described with field identification marks, the author's field observations, and notes on edibility, when and where to find it and microscopic characters. The illustrations are a good aid to specimen recognition.

MUSHROOM FEAST. J. Grigson. Knopf. \$12.95.

What does one do with the mushrooms once they are collected and near the pan? Jane Grigson has the answers. This collection of recipes is intended for the preparation of the most commonly eaten mushrooms, e.g., *Boletus edulis*, *Cantharellus cibarius* and *Marasmius oreades*. The instructions range from using a few simple herbs to enhance flavors to concocting more complicated preparations with sauces. In addition the author provides information on the historical culinary uses of the species she discusses as well as bits of folklore. Some basic line drawings are provided with

the admonition that they are not to be used for name giving.

HOW TO IDENTIFY MUSHROOMS. Mad River Press.

A series of paperback pamphlets designed to aid the serious amateur with mushroom identification has been edited by Dr. David Largent of Humboldt State University. Two of these are of particular interest: *How to Identify Mushrooms to Genus 1: Macroscopic Features* by D. L. Largent, and *How To Identify Mushrooms to Genus 4: Keys to Families and Genera* by D. E. Stuntz. Line drawings are used where needed to illustrate mushroom features. These publications are best used to gain skill with the process of mushroom identification, rather than to identify individual species.

MUSHROOMS OF NORTH AMERICA. O.K. Miller, Jr. 1981. E. P. Dutton. \$11.50.

This excellent reference can be used anywhere in the USA. Accordingly, some of the species that are more likely to be encountered in southern California are not featured. The introduction includes a discussion of mushroom toxins. Each species is well described, and recommendations for edibility are made. The illustrations are mostly color photographs and are well presented.

THE AUDUBON SOCIETY FIELD GUIDE TO NORTH AMERICAN MUSHROOMS. G. H. Lincoff. 1981. Alfred A. Knopf. \$12.00.

This fungus guide is written by a knowledgeable amateur who can be expected to provide accurate information. (His reference on mushroom toxins, *Toxic and Hallucinogenic Mushroom Poisoning, A Handbook for Physicians and Mushroom Hunters*, coauthored with D. H. Mitchel, M.D., is an excellent guide for those interested in plant poisonings, but alas, is out of print.) Stylized aids to identification, which use coined phrases, are provided. The photographs are separated from the descriptions for easy thumbing. The color photographs are well presented. The text provides a description, season, habitat and range for each species, as well as the author's comments.

The Audubon Society producers of the

field guide insisted on creating a common name for each and every one of the 703 fungi described. "Dirty Trich" for *Tricholoma pardinum*, "Moose Antlers" for *Wynnea americana*, and "White footed Slime" for the myxomycete *Diachea leucopodia* are some of the funnier examples. I suppose they wanted to lessen the burden that having to know the exact scientific name has for the amateur. The result is that author Lincoff made up lots of silly sounding names.

MUSHROOMS DEMYSTIFIED. A COMPREHENSIVE GUIDE TO THE FLESHY FUNGI OF THE CENTRAL CALIFORNIA COAST. D. Arora. 1979. Ten Speed Press. \$11.95.

This book is a publication by a well intending amateur. The photographs are black and white. The author provides his own commentary on each species, many of which range beyond the central California coast. The introductory part points to the author's perception of the major problem of mushroom name giving — academia. He chides the professional mycologist for inflexibility. But the author's attempts at demystification in this book only further cloud the issues. The major mystery of this work is where the information was derived. Aside from a list under the heading, "Suggested Readings and References," the author gives no indication of how he obtained his data. A disclaimer in the front of the book disavows responsibility for mistakes in identification by users.

MUSHROOMS OF WESTERN NORTH AMERICA. R. T. Orr and D. B. Orr. 1979. University of California Press. \$6.95.

This is an example of a publication that is from a reputable source but that is questionable because of inaccuracies.

Dr. Reynolds is Curator of Botany at the Natural History Museum. His primary research interest is tropical fungi.

The Quest for a Celestial Meter Stick

BAJA CALIFORNIA OBSERVATIONS OF THE TRANSIT OF VENUS IN 1769

by DOYCE B. NUNIS, JR.

The scientific community of the Western world was permeated with excitement and high expectation in 1769. From Russia to the New World, a host of men interested in science and its advancement, professionals and enthusiastic amateurs, awaited a signal event that was to take place on June 3—the transit of Venus across the face of the sun.

The transit of Venus, which occurs in a regular cycle of 243 years, was first recorded by a pair of self-taught English astronomers in 1639. These two pioneers established that the planet Venus crosses the face of the sun every 105.5 and 121.5 years, that the transits always come in pairs, and that the interval between each transit in a pair is only 8 years. Thus the next opportunity for scientists to witness the event would occur in 1761 and 1769. The Western world's astronomers considered the occasion as the premier astronomical event of the century. Little wonder. The transits would not occur again until 1874 and 1882, and they would not take place at all in the twentieth century (the next transits will occur in the years 2004 and 2012).

Thus the scientific community had made elaborate plans to record the 1761 transit. But when the results were tabulated, there was widespread disappointment. What the astronomers hoped to establish by observing the transit was the sun's mean distance from the earth. The precise practical problem was to measure the solar parallax, which is the angle formed by two places of observation and the point observed. Without exaggeration, the correct calculation of that measurement was considered one of the primary goals of physical astronomy in the eighteenth century. In his 1959 book on the transits of Venus, Harry Woolf noted that the measurement of the solar parallax, when obtained, would have provided the early scientists with a "standard measure for the universe, a kind of celestial meter stick of no less importance than its terrestrial counterpart." A correct measurement would in essence



A 1762 portrait of the French astronomer Chappe, which was acquired recently by the History Division of the Natural History Museum. The portrait, done in chalk and pastels by the French artist Jean Martial Fredou, later was engraved. The original is now on display in the Museum's exhibit, "California and the Southwest, 1540–1940."

fill a fundamental void in Newton's mechanics and Kepler's laws of planetary motion. Thus, as Woolf explained, one of the overriding concerns of eighteenth-century science was "to complete this gap in the Newtonian System of the World to solve the problem of the exact scalar determination of the solar system."

Today, we have more sophisticated techniques, which provide more reliable data on the scale of the solar system. Not so in the eighteenth century. When the 1761 observation results were tabulated and proved inconclusive, the scientific community girded itself to exploit to the maximum advantage the century's last chance to record the transit. One of the severe criticisms of the 1761 observations was the lack of observation posts on the west coast of North America and in the South Pacific. Both of these

areas would be covered in the plans for the 1769 observations.

The British government underwrote the first voyage of James Cook to the South Pacific to record the 1769 transit. Accompanied by Charles Green, the astronomer, and Joseph Banks, a wealthy Fellow of the Royal Society of London, Cook traveled to the appropriately named Point Venus on King George Island, now called Tahiti, where Green made an observation of the transit.

Plans for an expedition to the west coast of North America also had been initiated by the British through the auspices of the Royal Society. However, those plans received the Spanish crown's adamant disapproval. Instead, the French—who were allied to Spain by treaty and by the sharing of members of the Bourbon family as monarchs—were given permission to send a small expedition to Baja California. The French party was to be accompanied by a Spanish-sponsored scientific group. As a result, the first planned scientific expedition to the west coast of North America was launched.

The small French contingent was led by one of the nation's brilliant astronomers, Jean-Baptiste Chappe d'Auteroche, a Jesuit-trained scientist, who was on the staff of the Paris Observatory and a member of the French Royal Academy of Sciences. Chappe had distinguished himself in numerous astronomical undertakings, not the least of which was his extraordinarily daring and courageous trek to Tobolsk in Siberia to record the 1761 transit in a crude observatory he constructed for that unique occasion. No doubt it was that achievement that earned him the commission to go to Baja California to record the 1769 transit. Joining Chappe were Pauly, a geographer and engineer; Alexander-Jean Noël, a pupil of the Academy of Painting; a watchmaker named Dubois; and a personal servant.

The French contingent sailed from Le Havre, France, on September 28, 1768, and reached Cádiz, Spain, 21 days later. There they were to languish an inordi-



The burial procession for Chappe, who died in San José del Cabo, Baja California, in 1769. Drawing by Alexander-Jean Noël, the young artist who accompanied Chappe on the expedition to the New World. Courtesy of Musée du Louvre, Paris.

nate amount of time because of Spanish bureaucratic procrastination. Finally, after the direct intervention of the French ambassador, a small brigantine was provided for the passage to Veracruz, New Spain (Mexico). When the vessel sailed on December 21, the Frenchmen were joined by their Spanish counterparts, Vicente de Doz and Salvador de Medina, two naval officers and astronomers assigned to undertake the transit observation for Spain.

The uneventful but lengthy voyage almost ended in shipwreck on entrance to a storm-tossed Veracruz harbor on March 6, 1769. Carlos Francois de Croix, Marqués de Croix, the viceroy of New Spain, alerted by the Spanish government as to the importance of the expedition, provided generous logistic support and hospitality to the company en route via Mexico City to San Blas, a port on the west coast. The party reached San Blas on April 15, after an arduous overland trip. From there, the men were to sail to Cabo San Lucas, their ultimate Baja California destination.

Time now became a matter of deep concern. The transit would take place on June 3, and a quick passage across the Gulf of California was imperative. But such was not to be had. The voyage, which began on April 19 on the packet boat, *La Concepción*, was plagued by seemingly endless days of calms and contrary winds and currents. After continually insisting that the earliest landing should be made, Chappe finally prevailed. On May 19, the ship anchored off the mouth of the little river near which Mission San José del Cabo was situated.

On reaching the mission, the expedition again found itself being provided for, now out of the largess of Visitor General José de Gálvez, who had only recently completed a tour of inspection in Baja California. Prior to his departure for the mainland, he left orders that every courtesy and assistance was to be rendered to the expedition on its arrival.

Under the umbrella of such hospitality and generosity, Chappe hastened to establish himself at the mission and make the required preparations for preliminary observations. No time was lost. He recorded in his journal:

Myself and all my train took up our abode in a very large barn. I had half the roof taken off towards the south,

and put up an awning, that could be spread out or contracted at will. All my instruments were fixed just as they were to stand to observe the transit of Venus. The weather favoured me to my utmost wish. I had full time to make accurate and repeated observations for the setting of my clock. At last came the third of June, and I had an opportunity of making the complete observations.

This was his last entry; his journal ends there. Shortly after writing that paragraph, he took ill and subsequently died.

Prior to the arrival of the expedition at San José del Cabo, a plague of "epidemic distemper" had raged in the environs of the mission and had claimed the lives of one-third of the population. Chappe and his party might have escaped the epidemic if they had moved southwest to Cabo San Lucas. Indeed, Doz and Medina strongly recommended such a prudent course. But Chappe was more apprehensive over missing the transit than over the danger of the plague. Daily, as local inhabitants died from the contagion, Chappe thought of little else except the transit. That commitment was what counted; he would not waiver.

Oblivious to the dreadful threat surrounding him, Chappe used the 15 days prior to the transit to arrange the observatory, check the performance of the instruments, and measure the latitude and longitude of San José del Cabo. He noted in his journal that "piers of masonry were constructed to support the fundamental instruments," and that his 10-foot Dollond telescope "was mounted upon an upright mast." All was in readiness by May 31.

Doz and Medina were equally busy making their own preparations. Anticipating the lack of suitable timber in Baja California, they had supplied themselves at San Blas with what they "considered necessary for the construction of an observatory capable of holding [their] instruments with safety and convenience." When they had arrived at San José del Cabo, they found only six Indians to assist them; however, thanks to José del Gálvez, soon a sufficient number of Indians were available for work.

In consultation with Chappe, Doz and Medina decided to undertake separate

observations. Each would work independently; results would then be compared. And so they set to work constructing an observatory. Doz described the building extensively in his official report. When the structure was finished, it measured some 60 feet long and 20 feet wide. The two naval men then labored on, mounting their instruments. Their astronomical equipment included a British-made pendulum, quadrant, and micrometer; two telescopes were installed, one 14 feet and the other 10, plus a "new parallax machine of mahogany" 3 feet in length, which was built especially in Cádiz and patterned after a similar instrument that Chappe had brought with him from Paris. By May 28, Doz and Medina had all in readiness. They commenced observations to verify the latitude of San José del Cabo and to adjust their pendulum in anticipation of the transit, which was near at hand.

The weather proved ideal when the great day came. On June 3, the transit was meticulously observed and recorded. Following his written program designed on board ship on the tedious passage from Cádiz to Veracruz, Chappe made the observations while his servant counted out the seconds; Pauly recorded the minutes and took notes; Dubois assisted with the instruments. The findings attest to Chappe's skill and scientific ability; they are among the most precise tabulated for that year's transit.

While Chappe was engaged in his observations, Doz and Medina were each independently recording their own. The three sets of data, recorded at the same place, contain slight variances. In essence, Chappe's measurement would place the mean distance of the sun from the earth at 96,162,840 miles as compared to the Doz/Medina mean distance of 98,480,020 miles. (Modern measurement places the distance at 92,956,200 miles.)

Other observations of the transit of Venus were made in the New World in 1769. Don José Antonio Alzate y Ramírez, destined for a distinguished career in science, undertook a partial observation from Mexico City. At Hudson's Bay, under sponsorship of the Royal Society, Joseph Dymond and William Wales ably executed their assignment at Fort Prince of Wales on the Churchill River; in British Canada, Thomas Wright viewed the transit at Pale Coudre near Quebec. British America also had a plethora of observers, in contrast to the solitary expedition of John Winthrop to Newfoundland in 1761. Among the 1769

observers were John Leeds in Talbot County, Maryland, some 10 miles east of Annapolis and 12 miles west of Cape Henry; Owen Riddle and Joel Bailey near Lewistown, Pennsylvania; John Winthrop at Cambridge, Massachusetts; Benjamin West and a group of associates at Providence, Rhode Island; a group of eight at Norristown, Pennsylvania—Thomas Coombe, John Ewing, John Lukens, David Rittenhouse, John Sellers, William Smith, Joseph Shippen, and Dr. Hugh Williamson. The reports prepared by Rittenhouse and West offered the best colonial American data. Lastly, a second French expedition headed by Alexandre-Gui Pingré and the Comte de Fleurieu recorded a portion of the transit from the colony of Saint-Domingue (modern Haiti).

But most curious of all is an additional observation undertaken in Baja California by Joaquín Velázquez Cárdenas de León at Real de Santa Ana, a "settlement or mining camp" situated 5 miles south of the present town of San Antonio, some 45 miles south of La Paz. On departing Baja California, Gálvez had appointed Velázquez administrator of the royal mining district at Real de Santa Ana. An extremely well-educated man and a self-taught astronomer, Velázquez had earned for himself an established scientific reputation in Mexico City; there, Gálvez had come to know and admire him. When plans were finally approved for the visitor general's inspection trip to Baja California, Gálvez extended an invitation to Velázquez to join him: his skills could be used in organizing and expanding ore production in the mines, and that endeavor could then serve as a model for all mining



A portrait of Velázquez, the Mexican-born astronomer. Courtesy of the Trustees, British Museum, London.

operations in Mexico's interior provinces and to stimulate prospects for new discoveries. A second task given to Velázquez was to measure with greater accuracy the longitude of the bay of Cerralvo in Baja California to improve navigation, as well as to undertake other important astronomical observations, an assignment no doubt sparked by the news from Madrid that a French and a Spanish party of astronomers were en route to Baja California to record the transit of Venus.

On arrival at Real de Santa Ana, Velázquez began a series of observations that led him to discover the enormous error in the longitude that all previous maps had assigned to the peninsula. The

error was in excess of 5°, about 350 miles too far west.

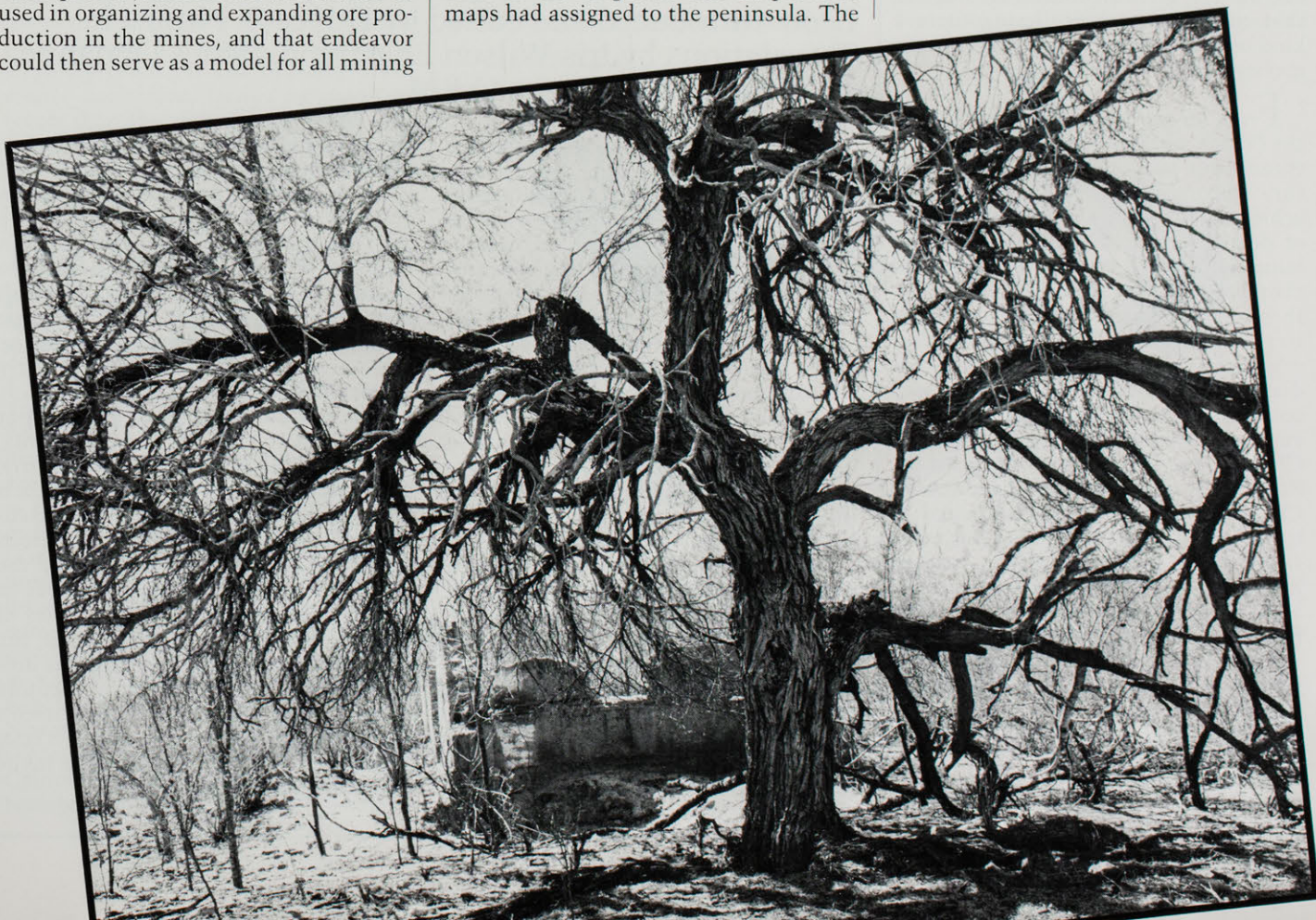
It is unclear whether or not the European scientific party met Velázquez prior to the transit of Venus. This much is clear: they were in touch with each other although separated by 55 miles.

Although Velázquez had not been recruited by Gálvez specifically to record the transit of Venus, he found himself equipped to do so, having already constructed an observatory in Real de Santa Ana, from boards of mimosa, and having determined the longitude of that settlement through observation.

The day after the transit, June 4, Velázquez sent an extract of his observation, written in Latin, to Chappe; a second copy, in Spanish, was also dispatched to Doz and Medina. Alexander von Humboldt later wrote: "The French traveller [Chappe] remained surprised at the agreement had between his observation and that of Velázquez. Without doubt he wondered at encountering in [Baja] California a Mexican who, without belonging to any academy nor having ever left New Spain, did as well as the academicians."

On Chappe's death, Velázquez negotiated the purchase of the French scientist's instruments. With these, he was able to perfect his findings by ascertaining with greater accuracy the exact location of his observatory in Real de

The ruins of buildings at Real de Santa Ana, the observation post of Velázquez. Photograph by Harry Crosby.





The road to Real de Santa Ana, as desolate today as it must have been in the eighteenth century. Photograph by Harry Crosby.

Santa Ana. In due course, he transmitted his observations to his superiors. It also became Velázquez's sad duty to inform the authorities of the tragedy that had overwhelmed the European party when disease wrought deadly havoc among them at San José del Cabo.

Gálvez fully informed the Mexican viceroy, Marqués de Croix, of all he had done to expedite the work of the academicians. He also was able to report that the astronomers "had fulfilled their mission successfully, having had time to regulate perfectly their instruments before June 3, by means of mechanics from Santa Ana." As for the observation itself, Gálvez wrote that the day proved "so serene and clear as was required to register the planet to their entire satisfaction." Gálvez also noted that "Don Joachim Velázquez made the same observation at Real de Santa Ana." In closing, the visitor general ominously related that the party was "suffering there a kind of tertian fever," little realizing the gravity of that remark.

From an astronomical point of view, the French and Spanish expedition was a triumphant success for eighteenth century science. But the splendor of that achievement was dimmed by the shadow of death. The contagious disease that hung like a pall over San José del Cabo claimed not only the life of Chappe but those of Medina, the clockmaker, the interpreter, twelve soldiers, four officers sent from Mexico, and about fifty Indians. The news of the tragedy was brought to Paris on December 5, 1770, by Pauly. On December 7, Pauly deposited Chappe's journals and manuscripts at the Royal Observatory with the director, Cassini de Thury. He was presented to the king and the French Royal Academy. Louis XV, a grateful monarch, granted him a pension of 800 francs. From the accounts of Pauly and the other survivor, the young artist, Alexander-Jean Noël, the intimate details of the last days of Chappe and his colleagues were dutifully transcribed for posterity.

The plague at San José del Cabo reaped a heavy toll. Pauly recounted that the "burning heat and the insects that inces-

santly preyed upon us, accelerated the progress of disease." Without food, the party was reduced to eating sour native fruits provided by the Indians. Medicines proved useless. Drinking stagnant, copper-laden water and eating wretched fruits only made the misery of the sick and dying more intolerable. But Chappe continued to labor to the end, sick as he was. Pauly later recalled that, when Chappe died on August 1, "our situation and our want of strength induced us in this case to bury him without much cere-

mony." Before he died, Chappe had asked to be buried in a Franciscan habit. His wish was duly honored. Doz and Medina, in the absence of a priest, performed a secular burial rite. Noël left two graphic scenes, one of San José del Cabo and the other of Chappe's funeral cortege.

The names of Chappe, Doz and Medina, and Velázquez have long been submerged in the musty pages of eighteenth-century books and journals. They warrant something better. Their rightful place in the history of science, in the history of astronomy, should be secured. For their heroic observation of the 1769 transit of Venus on a lonely, desolate peninsula, they deserve the accolade of Baja California's first scientists, its first astronomers. Even more. They were the first astronomers to exercise their profession on the west coast of North America, where they constructed the first observatories. Theirs was the region's first scientific expedition. As such, it was a major accomplishment.

NEW MUSEUM PUBLICATION

The 1769 Transit of Venus: the Baja California Observations of Jean-Baptiste Chappe d'Auteroche, Vicente de Doz, and Joaquín Velázquez Cárdenas de León. Introduced and edited by Doyce B. Nunis, Jr. Translations by Iris Wilson Engstrand, James Donahue, and Maynard J. Geiger, O.F.M.

The transits of Venus across the face of the sun in 1761 and 1769, and again in 1874 and 1882, were of great importance to the international community of astronomers. These events had been anticipated since 1679, when Halley indicated their value in determining the solar parallax, the mean distance between the earth and sun, and thus the spatial scale of the solar system. Computation methods required different sets of observations of each transit from widely separated points of the globe, and scientists of many nationalities made observations in both centuries, stationing themselves in remote places and enduring great hardships in their efforts.

In 1769, the French astronomer, Chappe, and two Spanish astronomers, Vicente de Doz and Salvador de Medina, journeyed together from Europe to Baja California to observe the transit of Venus. The peninsula was also the observation place of Mexican-born Joaquín Velázquez Cárdenas de León, a self-taught astronomer. These men were the first scientists to collect and record scientific data on the California coast. The accounts of

their observations are united for the first time in this new book.

An extensive introduction by Nunis contains biographical information on the men, an account of their adventures in the New World, and a description of the scientific and political context in which they worked. In addition to documenting individual courage and perseverance, the book gives a vivid impression of early scientific methods.

Doyce Nunis is professor of history at the University of Southern California, Editor of *Southern California Quarterly*, and Research Associate of the Natural History Museum. He has written and edited a number of books on the American West. His new book, published by the Natural History Museum, is Number 46 in the Baja California Travels Series of Dawson's Book Shop. Because of the special subject matter, the edition is limited to 500 copies. It was set in Berthold Bembo types and printed on Warren's Olde Style paper at The Castle Press, Pasadena, California. It is available in the Museum Book Shop.

(Continued from page 2)

disconcerting to the researchers. However, this "natural experiment" gives Schreiber an opportunity over the coming years to study the repopulation of the island and the reestablishment of the breeding seasons. The dead young also provided a valuable series of skeletons for the Museum collection.

MALACOLOGY EXPEDITION TO JAPAN

In September, two members of the Malacology Section, Dr. James H. McLean, Curator, and Mrs. Edith Abbott, long time volunteer in the section, visited Japan to study and collect marine mollusks.

McLean's research involved the study and preservation of living animals in the Trochacea, a group of snails commonly known as the topshells. Representatives of genera not occurring in California were found, enabling him to complete a revision of the family level classification in the group. The work was mostly conducted at marine laboratories—for which Japan is famous—in three different regions of the country, the Asamushi Laboratory in northern Honshu, the Seto Laboratory in south-central Honshu, and the Amakusa Laboratory in Kyushu.

Although the mollusk fauna of Japan is well known to Japanese malacologists, few American malacologists have conducted field work there, and the Japanese fauna is poorly represented in American museums. McLean and Abbott therefore took the opportunity to collect as many different species of seashells as could be found over a period of about five days in each locality. Thousands of specimens were collected for the museum's reference collection, including many no bigger than the size of sand grains. The smallest specimens remain to be extracted from samples of sand and gravel taken from each locality.

CURATORS & COLLECTIONS

CALIFORNIAN FACES FROM THE PAST

Pico, Sepulveda, and Dominguez—these are some of the Hispanic surnamed people whose portraits hang in the museum in an exhibit called, "Californian Faces from the Past." The names of these California pioneers sound familiar because boulevards and cities have been named in their honor. Now their portraits are displayed together for the first time in a major new exhibit that begins in February and continues until next November.

Most of these oil portraits depict native Californians, men and women who were born before the state entered the union in



Pio Pico was governor of California twice, 1832–1833 and 1845–1846. Born at San Gabriel Mission in 1801, he lived most of his life in southern California, and died in Los Angeles in 1894.

1850. Some of them were born before 1821, when California was still a province of Spain; others were born under Mexican rule, between 1821 and 1848.

Among them were ranchers, politicians, and professionals; mayors of Los Angeles and Santa Barbara, a Los Angeles County supervisor, a doctor, a governor, and leading citizens of several southern California communities.

Along with the portraits are biographical summaries, and in many cases, daguerreotypes and photographs of the subjects. Family trees of the extensive Pico and Sepulveda clans help explain relationships of a number of the people whose portraits are part of the exhibit.

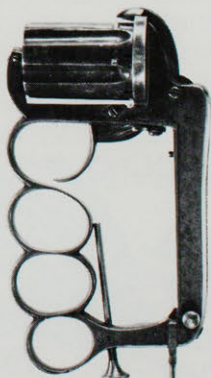
HISTORY'S "NEW ACQUISITIONS" CORNER

The History Division recently inaugurated an exhibit space on the ground floor stairway landing near the California and Southwest history hall that highlights new donations and purchases. In the first installation, widely differing kinds of historical artifacts are displayed.

In a specially built case, there are several unusual handguns, which are only a few from a large donation made by Paquita Machris. These weapons, all of distinctive styling, were used either for personal protection or as experimental models; none of them was military issue. Among them are multiple barrel pistols and guns that incorporate edged weapons in their mechanisms.

An all-metal prospector's mining kit, made up of seven pieces that fit into a compact unit, was used by a hopeful miner in Arizona's Kofa Mountains in the 1920's. Other mining artifacts displayed include two gold mining certificates from Arizona and Sonora enterprises. These have been added to the division's large collection of such certificates, which are important as much for the graphic depictions of landscape and mining scenes on them as for their documentary value of mining operations.

On the *lighter* side, the new case also includes several turn-of-the-century fire engine lanterns and an "art nouveau" lamp donated by Jeff Gore. This table lamp, dating from the early 1900's, has a bronze base cast in the shape of a gnarled



An English "Duckfoot" revolver and a French "Apache" (left), a three-in-one weapon.

tree trunk, which is topped by a dome-shaped multi-colored leaded glass shade, done in a floral pattern. In the exhibit, the lamp is illuminated so that the glass colors are visible to museum visitors.

From time to time, new and interesting acquisitions will be shown in this display.

MEMBERS OPEN HOUSE

You are invited to participate in an adventure at the Natural History Museum annual MEMBERS OPEN HOUSE on March 21, 1983, from 4 to 10 p.m. featuring:

- A behind-the-scenes look at our fabulous collections.
- A silent movie entitled "Death Trap Of The Ages," which describes

how fossils were collected from the La Brea Tar Pits in the early days.

- Docent tour guides to point out treasures on display.
- A chance for junior members to cast replicas from fossil shark teeth and trilobites!

To make reservations for this FREE museum adventure call the Membership Office, 749-3631. The cafeteria will be open for your convenience.



VANISHING WILDLIFE IN CALIFORNIA

Before human settlers made their way into our state, California had magnificent wildlife, living along our shores, in coastal wetlands, on oak-grassland hills, near wild rivers, in deserts, and among the granitic peaks of the Sierra Nevada. However, humans have moved in on these habitats, and their assault on the wildlands and their wildlife has been spectacular, indeed. Today, we may still see our first residents and where they live, although some are in danger's way.

In recognition of the threat to our state's wildlife, a unique three-year field project was begun by noted nature photographer Tupper Ansel Blake with support from the California Department of

Fish and Game and the National Audubon Society as well as corporate and private donors. Blake's stunning color photographs have been assembled into an exhibition called *The Wildlands and Wildlife of California*. Seven main California habitat zones are featured in the show; wildlife recorded by photographer Blake include King Salmon leaping from a foamy stream in their frenzied journey, a small family gathering of the rare San Joaquin Kit Fox, horned toads scuttling over sand dunes, and a solitary Bald Eagle screeching over its prey on an icy lake.

The exhibition opens at the Natural History Museum on March 1, and continues through June 5, 1983 in the Director's Gallery. We are pleased to display these color images not only to advance public appreciation and understanding of

these resources, but as a reminder to us all of our fragile and diminishing wildlands and wildlife.

GREENLAND ESKIMO EXHIBIT

Beginning February 10, 1983, and continuing through April 17, 1983, the Museum will be host to a special traveling exhibition entitled "A Town in Greenland." Through photographs, drawings and artifacts, the exhibit traces the growth of the Eskimos of Greenland from a hunting society to a people rapidly entering the industrial age.

The human occupation of Greenland began approximately 4,000 years ago when the climate was much more favorable than it is today. Various waves of settlers were attracted to the area over the succeeding centuries depending on climatic fluctuations.

The unique adaptation of these peoples to their harsh environment is explored in the first part of the exhibit. Some of the artifacts that typify this life-style will be on display in the form of fur clothing, a skin-covered kayak and a full-size dog sled pulled by a team of huskies.

Because of its remote location and Danish protectionism, Greenland Eskimo culture changed very little until after World War II. As a Danish colony for over 200 years, Greenland had been protected from outside influences until American military bases were established there during the war. Since that time, Greenland has taken several gigantic leaps towards becoming an industrial society, beginning with the establishment of Home Rule in 1979.

The second part of the exhibit explores conditions in Greenland today includ-



Doll dressed in traditional Eskimo costume



A sixteenth-century artist's conception of a meeting between a Greenland Eskimo and a European ship.

ing its main industry of cod and shrimp fishing as well as its potential for development in the areas of oil and mineral reserves. The exhibit documents the unique struggle of the Greenlanders to direct and control their participation in modern society while retaining the best of their ancient Eskimo heritage.

We invite you to come and meet and learn about the 50,000 inhabitants of the world's largest island as part of *Scandinavia Today*, an American celebration honoring the cultural and intellectual life of modern Scandinavia. Our exhibit is only one part of this major event in which the five Scandinavian countries are sending their most treasured art objects to the United States, as well as their leading artists, writers, performers and scholars. All will be featured in programs offered in Los Angeles, New York, Washington, D.C., Minneapolis, St. Paul, Seattle, Chicago and Houston.

The Los Angeles celebration begins in February 1983. Members of the Los Angeles cultural and corporate communities have joined with the Scandinavian community to produce a rich and varied program. Also participating are the American Scandinavian Foundation, the Secretariat for Nordic Cultural Cooperation, the governments of Denmark, Finland, Iceland, Norway and Sweden, the National Endowment for the Humanities and the National Endowment for the Arts. Joining together, these organizations will provide Los Angeles with a comprehensive and unforgettable introduction to Scandinavian fine arts, crafts, dance, film, music, literature and science.

LECTURE IN CONJUNCTION WITH GREENLAND EXHIBIT

Dr. Wendell H. Oswalt, Professor of Anthropology at UCLA and recognized Eskimo expert, will present a slide lecture entitled "Vikings & Eskimos: Contact and Conflict in Greenland" on Friday evening, February 25, 1983, at 7:00 PM.

Dr. Oswalt will discuss the earliest Norse experiences in Greenland over a thousand years ago focusing on Eric the Red and other Viking explorers, their travels westward from Iceland, their attempts to colonize new territories and their contacts with local Eskimos.

After the slide lecture, there will be an opportunity for those attending to meet and talk with Dr. Oswalt at a wine and cheese reception as well as a chance to view the exhibit "A Town in Greenland." Additionally, copies of Dr. Oswalt's many books on Eskimos will be on hand in our Book Shop available for autographing.

Tickets for Dr. Oswalt's lecture, reception and exhibition viewing will be \$5.00 for Museum Alliance members and \$7.00 for nonmembers. Checks should be made out to "Museum Alliance," and sent to: 900 Exposition Blvd., Los Angeles 90007. Please include a stamped, self-addressed envelope with your order.

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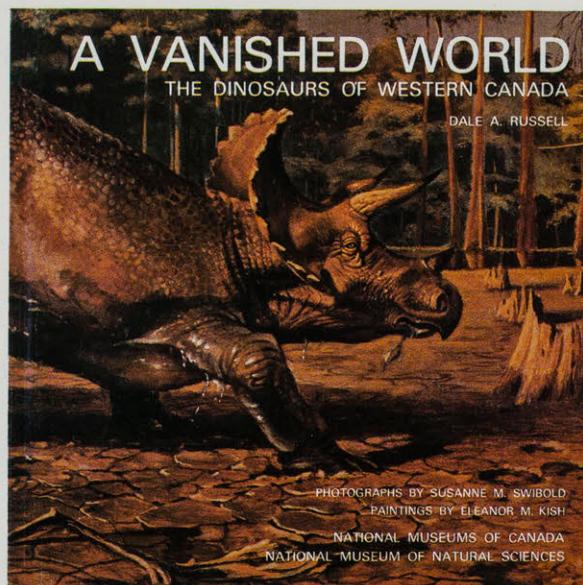
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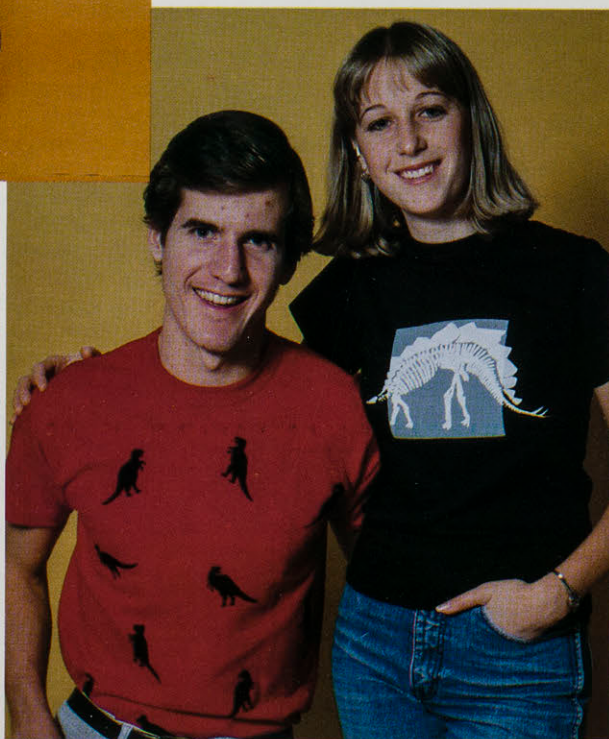
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An assortment of colorful T-shirts brightly silk-screened with dinosaur designs. Left, *Tyrannosaurus rex*, adult's sizes: \$13.00, children's sizes: \$10.00. Right, *Stegosaurus*, adult sizes only: \$12.00.



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